THE AIRPORT AND THE ENVIRONMENT: A STUDY OF MOUNTAIN VIEW, GEORGIA

A THESIS OPTION PAPER

Presented to

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By

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DEDICATION

To Judy,

Again.

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CHAPTER ONE

INTRODUCTION

Aviation has grown dramatically and today is a major field of technology influencing modern society. Air travel has become common throughout the world and many countries with only primitive road systems have modern airports. Most of this growth has occurred in the last 25 years. The number of air travelers worldwide has increased from nine million to more than 287 million since 1952.[1]

To accommodate continued growth in aviation, cities now face decisions to either expand their existing airports or to build new ones. Along with this decision, planners must decide if new airports are to be built near the city or at remote sites. Locations that are close to the city center offer the advantages of convenient access and employment opportunities for urban residents. However, close-in locations present obvious problems such as noise impact, accident potential, and congestion in surface transportation serving the airport.

The recent trend in airport planning has been to place airports far from populated areas, thereby using distance as a solution to the problems of noise and disruption. However, this strategy has met with two basic problems. First, people often decide against the long trip to the new airport site and, instead, use the old one. Second, urban development, which the remote airport site was designed to avoid, has ultimately followed the facility to its new location.[2]

Attention is now being given to developing ways to improve and upgrade existing airports, including those in heavily-urbanized areas. Almost every major city has an airport in its general metropolitan area. Atlanta, Los Angeles, San Francisco, New York, Chicago, and Miami are just a few of the cities that are seeking ways to keep their close-in airports active and viable.

Integrating a major airport into an urban area presents one of the greatest challenges to ever face planners, engineers, and public officials. There is no set of complete answers to the myriad of problems that must be solved, such as noise impact, provision of access routes to the airport, and control of development around the facility. Any significant improvement in reducing airport impact will require a combination of efforts on the part of everyone associated with cities and their development.

Purpose of the Study

This thesis proposes to assess the magnitude of airport impact and to explore the problems of integrating a major airfield into the fabric of a highly-developed urban area. A complete analysis of all of the options available to help control airport impact is beyond the scope of this effort. The study will concentrate on the alternatives that are available to help communities minimize the negative impacts of airport operations. Methods such as technological improvements to aircraft, adjustment of flight patterns and operating procedures and administrative controls by airport managers are discussed only briefly.

The Study Setting

The present situation at Atlanta's Hartsfield International Airport is selected to illustrate the impact of a typical regional airport on the surrounding communities. Hartsfield International faces nearly every conceivable problem that can confront a major airport. The facility is the second busiest in the world and must expand to accommodate the steadily increasing air traffic in the area. It is heavily encroached upon from all sides, yet relief from a new airport to serve the area is decades away.

The study concentrates on the specific situation in Mountain View, Georgia, a small community adjacent to Hartsfield International. Mountain View was selected, as it experiences the greatest impact of airport-related activity in the Atlanta Metropolitan Area. Also, the City of Atlanta has initiated several programs to help alleviate the noise problem in Mountain View. These programs provide an opportunity to evaluate the progress that is being made in reducing airport impact and to assess the long-term effects of the various efforts.

Conduct of the Study

The objective of the thesis is to explore the concepts and methodologies available for analyzing the problem of airport impact and for preparing recommended solutions to the problem. To accomplish this, the specific problems which face Atlanta and Mountain View are quantified where possible and subjected to various forms of analysis. Where accurate information is not available, hypothetical data, or best estimates, are used as required to illustrate a particular concept or methodology.

The most obvious impact of airport operations is noise and it is addressed in detail throughout the report. However, there are other effects which should also be considered. One area that is discussed at length is the hazard presented by a potential airplane accident near the airport. This topic is explored in detail as it affects land use around an airport. One area that is not discussed is the problem of air pollution generated by aircraft. This topic is deferred due to the lack of adequate reliable data on the subject at the present time.

Chapters Two and Three identify the noise problem generated by the airport and how the noise affects Mountain View and other parts of the City of Atlanta. Chapter Two describes the impact of airport noise on the entire Metropolitan Atlanta

Area and illustrates how it may have affected the growth and development of different parts of town. Chapter Three discusses the general conditions that now exist in Mountain View and describes the extent of the noise problem in that area.

A discussion of the standards that are presently used to evaluate land use around airports and the methods used to analyze the effects of aircraft noise impact are contained in Chapters Four and Five. Chapter Four presents a summary of the criteria and guidelines that have been established to evaluate various types of land uses in the airport environment, while Chapter Five explores the economic impact of noise.

Chapters Six and Seven describe a program that approaches the airport impact problem from a land-use concept. Specifically, Chapter Six details the goals and objectives of such a program and outlines the steps to be followed in preparing a program. Chapter Seven describes the items to be considered in the preparation of a land use development plan for airport-impacted areas. Both Chapters Six and Seven address the problem in Mountain View in detail and propose several alternatives to deal with airport impact in that area. Chapter Eight provides a summary of the findings and conclusions derived from the study.

CHAPTER TWO

AIRPORT NOISE IMPACT AREA: DEFINITION AND ANALYSIS

This chapter identifies and analyzes the areas that are impacted by noise from Hartsfield International Airport. The analysis covers the entire region surrounding the airport, and does not focus on any particular area. The objective is to determine which areas are affected by airport noise, and then evaluate their relative standing in the Atlanta metropolitan area. Where possible, the effects that airport noise may have had on community development are discussed.

The first section describes the procedures that were followed to define the actual impact area, using established methods for determining community noise impact. The second section provides the analyses used to evaluate the different noise impact areas and compare them with the rest of the Atlanta SMSA. The third section provides a summary of the findings, and lists some of the items which should be considered in dealing with the problem of airport noise in Atlanta.

Definition of the Impact Area

Areas of noise impact were determined by selecting the census tracts affected by various levels of airport noise. Noise contours for Hartsfield airport are currently being developed by the Region IV office of the U. S. Environmental

Protection Agency (EPA). The preliminary results of the EPA study are used in this report as the basis for assessing airport noise impact in the Atlanta area.

The noise analysis is based upon aircraft operations during 1976. The study illustrates existing conditions only, and does not consider potential noise reductions due to engine modifications or operational noise abatement procedures. Also, the analysis does not consider the impact of the additional aircraft operations expected with the completion of the mid-field passenger terminal.[3]

Description of Noise Zones

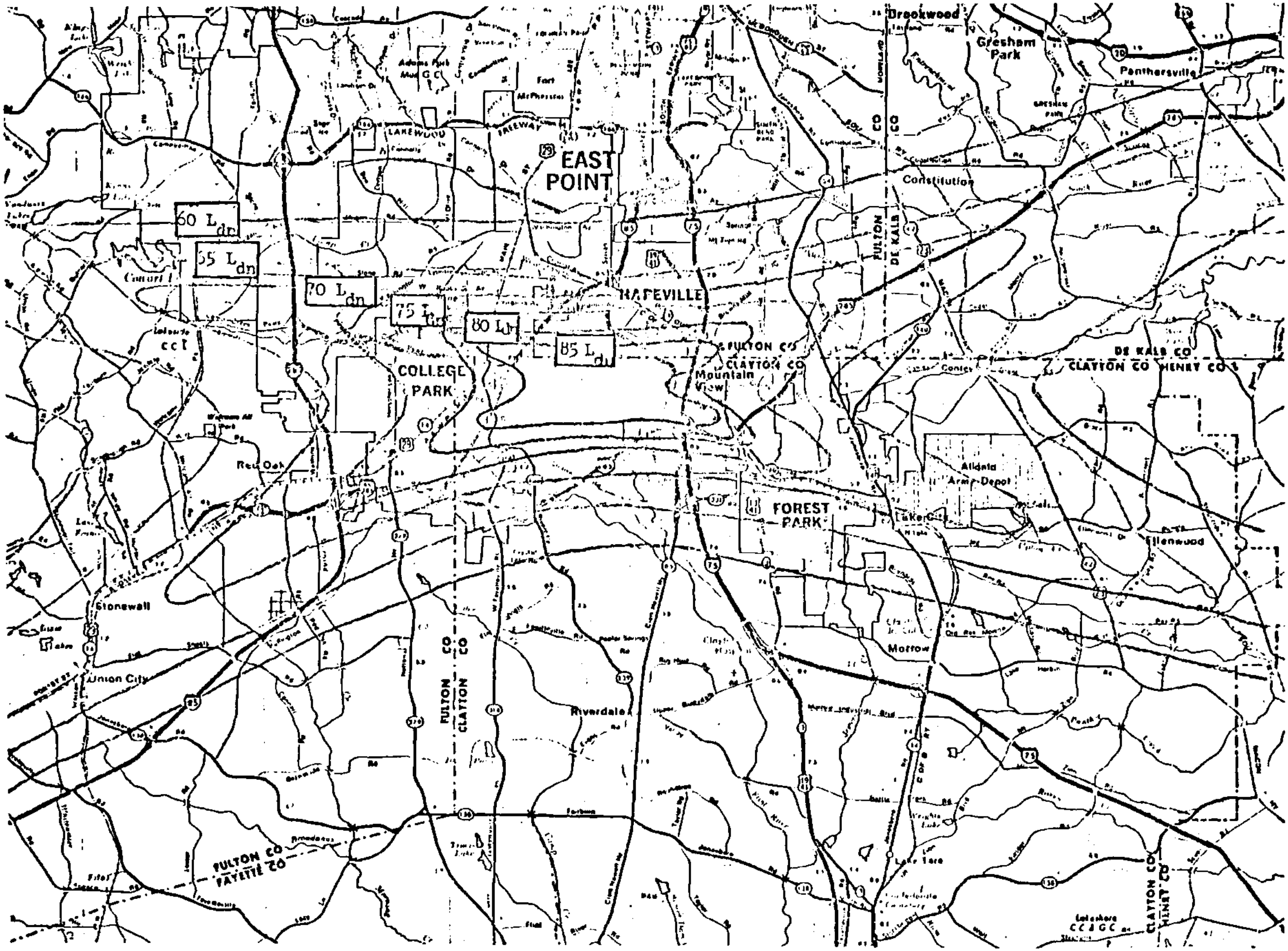
Figure 2.1 illustrates the projection of the noise levels developed by the EPA study, with contour lines representing areas of approximately equal noise exposure. The noise descriptor used to develop the contours is the Average Day-Night Sound Level, or L_{dn}. This descriptor is based upon noise in communities as it affects activities such as speech and sleep.[4] It measures total noise energy over a 24-hour period, with a 10dB penalty for nighttime noise.

The approximate relationships between the L_{dn} descriptor and other commonly-used measures such as Noise Exposure Forecase (NEF), Composite Noise Rating (CNR), and Community Noise Equivalent Level (CNEL), are as follows:

$$L_{dn} \doteq NEF + 35$$

$$L_{dn} \doteq CNR - 35$$

$$L_{dn} \doteq CNEL$$



Noise Level Contour with L_{dn} Rating

Figure 2.1. L_{dn} Noise Contours for Hartsfield International Airport

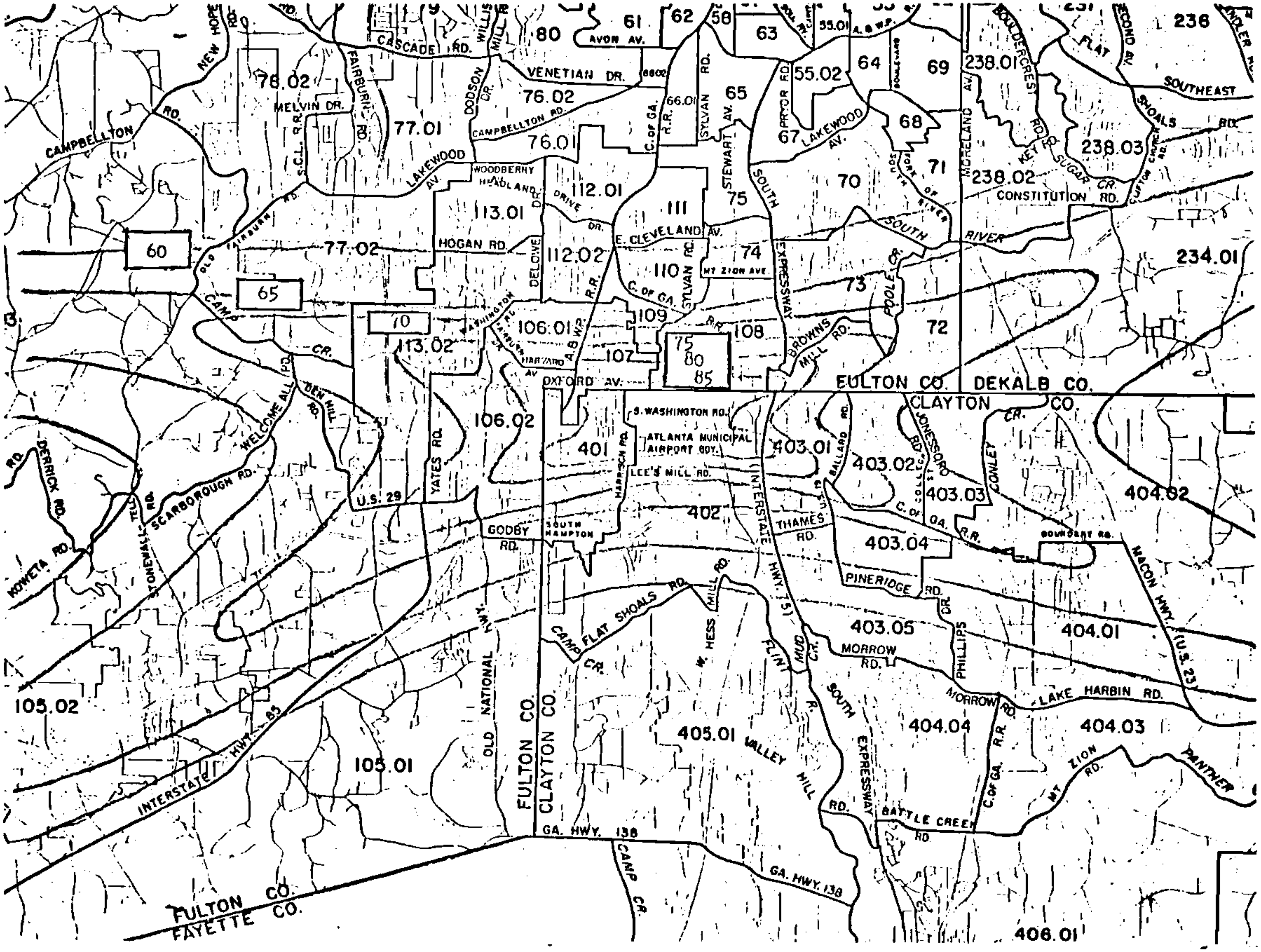
These are only approximations, as the four descriptors use different frequency weightings and allowances for noise duration. However, the conversions are generally accurate within ± 2 dB, and are used throughout the report where conversions to the L_{dn} descriptor are necessary.[5]

The contours illustrated by Figure 2.1 are approximate reproductions of those developed by the EPA study. Minor irregularities in the contours for L_{dn} 60 and 65 are not recorded on the map. However, all of the contours accurately represent the extreme inner and outer limits of the various noise levels.

Identification of Impacted Areas

Census tracts, as established by the U. S. Bureau of the Census, are used as the basis for categorizing noise-impacted areas. This procedure allows direct use of census information, and uses relatively small, but easily identified, areas. Figure 2.2 illustrates the projection of the noise contours onto a census tract map for the Atlanta metropolitan area.

A census tract is counted as "impacted" if at least half of its land area is within a noise contour. The use of whole census tracts simplifies the collection and evaluation of statistics, and should be reasonably accurate for evaluating the regional impact of airport noise. Therefore, no attempt is made to estimate portions of a partially impacted tract, nor to conduct a detailed block study for the analyses



Noise Level Contour with L_{dn} Rating

Figure 2.2. L_{dn} Noise Contours Impacting Census Tract Areas

in this chapter.

Census tracts impacted by airport noise are grouped into three categories:

(1) Census tracts in noise zone 75 L_{dn} and greater (High Impact Zone);

(2) Census tracts in the noise zone between 65 L_{dn} and 75 L_{dn} (Moderate Impact Zone); and

(3) Census tracts in noise impact zone 65 L_{dn} and greater (Total Impact Zone).

These three categories are selected to help illustrate the relative impact of various noise levels. Although many of the tracts are not exactly within one noise zone, the area of predominant impact can be determined.

The selection of the zones noted above is based upon noise exposure criteria developed by the U. S. Department of Housing and Urban Development (HUD). The HUD criteria specifies that: residences near airports are "normally acceptable" in areas of NEF 30 or L_{dn} 65; are "discretionary acceptable" in noise zones up to 40 NEF or 75 L_{dn}; and are not acceptable in noise areas above 40 NEF or 75 L_{dn}.[6]

It should be noted that the noise zones discussed above do not conform to the most recent EPA guidelines, which recommend against residential construction within noise zone 55 L_{dn}.[7] The EPA criteria was not followed, as accurate noise contour information was not available beyond noise zone 60 L_{dn}. Also, the study area would have been considerably larger, as the area covered by noise zone 60 L_{dn} measures roughly 14 miles by 34 miles. The HUD criteria, on the other hand, can be applied within noise zone 65 L_{dn}, which measures approximately 8 miles by 22 miles.

Table 2.1 lists the census tracts within the moderate and high-impact noise zones. The sum of these twenty census tracts also represents the area within the total noise impact zone. These noise zones and the respective census tracts include portions of three of the seven counties in the Atlanta metropolitan area, and eight of the area's 46 municipalities. College Park, Hapeville, and Mountain View are entirely within the 65 L_{dn} Contour, and a major portion of East Point and Forest Park are within the same zone. In addition, most of College Park and Mountain View are within the 75 L_{dn} noise zone, along with portions of East Point, Forest Park, and Hapeville.

Analysis of Noise-Impacted Areas

Analysis and comparison of the regional impact of noise was accomplished through statistical data studies. The basic sources for this information were the U. S. Census, and publications prepared by the Atlanta Regional Commission. The object of these studies is to determine what part the noise-impacted areas play in the total Atlanta metropolitan scheme, and to assess, where possible, the impact of airport noise on the growth and development of the area.

The specific areas that are studied in this section are as follows:

Population. Population growth trends over a six-year period, from 1970 to 1976, are analyzed. The percentage of families below the poverty income level is also

Table 2.1. Noise-Impacted Areas

Census Tract Designation	County	Municipality
Noise Zone 75 L_{dn}+		
72	Fulton	Atlanta
106.01	"	College Park
106.02	"	"
107	"	"
108	"	Hapeville
401	Clayton	College Park
402	"	(Unincorporated)
403.01	"	Mountain View
403.02	"	Forest Park
Noise Zone 65 - 75 L_{dn}		
73	Fulton	Atlanta
77.02	"	"
105.02	"	(Unincorporated)
109	"	East Point
113.02	"	"
234.01	Dekalb	(Unincorporated)
403.03	Clayton	Forest Park (Part)
403.04	"	"
403.05	"	" "
404.01	"	(Unincorporated)
404.02	"	"

compiled for each census tract.

Housing. Total housing available is compiled by census tract, with number of vacancies and vacancy rates, for a six-year period from 1970 to 1976.

Business and Employment. The numbers of businesses in each census tract between 1970 and 1976 are compiled, along with the total jobs available in the tracts during the same period of time.

Land Use. Land uses are grouped into five broad categories, and acreages compiled for each census tract. The categories include: residential; commercial/industrial; public (includes rights-of-ways, public facilities, and recreation areas); vacant, developable; and vacant, undevelopable, due to terrain, flood plain, or proximity to airports.

Statistics for each area of study are summarized by noise-impact zone, as described in the previous section of this chapter. Comparable statistics are also assembled for Fulton, Dekalb, and Clayton Counties, and the Atlanta Metropolitan Area. Summaries and comparable statistics for the counties and the Atlanta SMSA are included in the following discussions on each of the study areas.

Population

Table 2.2 illustrates a summary of the population from 1970 to 1976 for the Atlanta Metropolitan Area, for counties within the noise-impacted area, and for census tracts within the noise-impact zones. The table also shows the percentage of families with income below the poverty level as of 1970.

Based on the figures in Table 2.2, population in the total noise-impact area (65 L_{dn}+) increased by 27,500 or 22 per cent between 1970 and 1976. During the same period population in the Atlanta SMSA increased by 218,300, or

Table 2.2. Population in Noise-Impacted Areas

Area/Noise Zone	Population 1970	Population 1976	Change 1970 - 1976 #	Change 1970 - 1976 %	% Families Below Poverty Level in 1970
Atlanta SMSA	1,434,698	1,653,000	218,302	15	9.1
Fulton County	605,315	603,200	2,115	3.4	13.6
Dekalb County	415,387	464,200	48,813	12	5.5
Clayton County	98,043	132,700	34,657	35	9.1
High-Impact Zone	52,332	56,372	4,040	8	8.6
Moderate-Impact Zone	74,987	98,476	23,489	31	6.4
Total-Impact Zone	127,319	154,848	27,529	22	7.3

Source: Atlanta Regional Commission. <u>1976 Population and Housing</u>.

U. S. Bureau of the Census. <u>Atlanta, Ga. Census Tracts</u>. Income Characteristics of the Population, 1970.

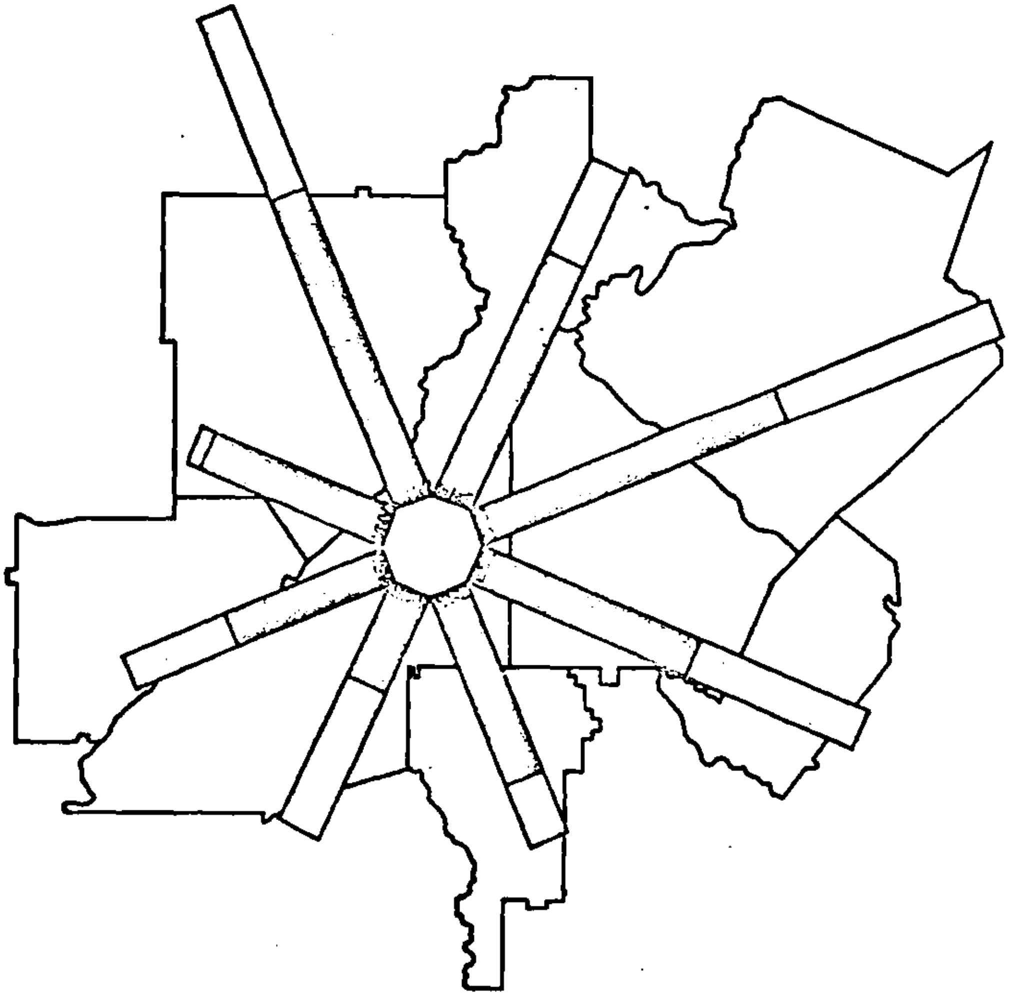
15 per cent. Figure 2.3 illustrates the directions of population growth in the Atlanta region. Although growth in the area around the airport has been relatively slower than for areas to the North and East, population has increased faster near the airport than for the total SMSA.

The percentage of families with income below the poverty level was slightly less for the total noise impact area than for the Atlanta SMSA. The noise-impact area also had a smaller percentage of poverty level families than did Fulton County or Clayton County.

Population growth in the high-noise-impact area increased by 4,040, or 8 per cent between 1970 and 1976. However, during the same period, population in the moderate noise-impact area increased by 23,500 or 31 per cent. It is interesting to note that the population growth in the moderate noise-impact area is double the rate for the Atlanta SMSA (15 percent), larger than for Dekalb County (12 per cent) and almost equal to Clayton County (35 per cent). The percentage of families with incomes below poverty level is slightly higher in the high-noise-impact area, but is still less than for the Atlanta SMSA, Fulton County, or Clayton County.

Based upon the above analysis, there is little evidence to indicate that moderate noise levels have an influence on an area's population growth. Population within the moderate noise-impact zone has grown at a relatively high rate. However, growth in areas of extremely high-noise impact is

DIRECTIONS OF GROWTH IN THE ATLANTA REGION



1960 - 1970

1970 - 1976

CENTRAL AREA, REPRESENTED BY OCTAGON, HAD A NET LOSS OF 98,224 PERSONS SINCE 1960.

NET POPULATION INCREASE
ATLANTA REGION

AREA	1960-1970	1970-1976
ENE	80,697	55,451
ESE	57,847	43,147
SSE	49,013	15,869
SSW	27,169	38,221
WSW	40,881	26,981
WNW	49,185	3,530
NNW	60,813	46,400
NNE	66,831	24,788

Figure 2.3. Population Growth in the Atlanta SMSA

Source: Atlanta Regional Commission

relatively less than for other areas, as population change in the high-impact zone has barely been positive. This may be attributed to noise as well as other factors such as quality of housing and economic development.

The statistics in Table 2.2 indicate that there may be some correlation between noise level and family income level. However, the trends are subtle, and may not be completely accurate, considering the inherent problems in evaluating poverty level income.

Housing

Table 2.3 illustrates the total housing units, vacancies, and vacancy rates for the period 1970 to 1976, for the Atlanta SMSA, the noise-impacted counties, and the different noise-impact zones. "Vacancies" refers to the total number of housing units available for rent or sale. "Vacancy rate" is determined by dividing the vacancies by total housing units. The statistics show that the number of housing units in the SMSA increased by 168,803, or 36 per cent, while the number of units in the total noise-impact area increased by 21,379 or 53 per cent. However, during the same period, the number of vacancies in the SMSA increased by 18,190, or 84 per cent, while the vacancies in the total noise-impact area increased by 3,160, or 174 per cent. Therefore, the vacancy rate in the SMSA increased by about one-third between 1970 and 1976, while the rate in the total noise-impact area almost doubled.

Table 2.3. Housing in Noise-Impacted Areas

	Housing				Vacancies				Vacancy Rate	
			Change				Change		1970	1976
Area/Noise Zone	1970	1976	#	%	1970	1976	#	%	%	%
Atlanta SMSA	464,606	633,409	168,803	+36	21,793	39,983	18,190	+84	4.7	+6.3
Dekalb County	129,712	173,229	43,517	+33	5,623	10,143	4,520	+80	4.3	+5.9
Fulton County	207,814	244,574	36,760	+18	10,259	16,053	5,794	+56	4.9	+6.6
Clayton County	29,440	49,075	19,635	+67	2,705	6,579	3,874	+143	9.2	+13.4
High-Impact Zone	17,800	23,571	5,771	+32	1,038	1,881	843	+81	5.8	+7.9
Moderate-Impact Zone	22,265	37,876	15,611	+70	776	3,093	2,317	+298	3.5	+8.2
Total-Impact Zone	40,062	61,441	21,379	+53	1,874	4,974	3,160	+174	4.5	+8.1

Source: Atlanta Regional Commission. 1976 Population and Housing.

Between 1970 and 1976, the number of housing units in the moderate-impact area increased by 15,611, or 70 per cent. During the same period, the number of housing units in the high-impact area increased by 5,771, or 32 per cent. However, vacancies in the moderate-impact area increased by almost 300 per cent, while the number of vacancies in the high-noise impact area increased by 81 per cent. Therefore, the vacancy rate in the high-noise impact area increased by a little more than one-third, while the vacancy rate in the moderate-noise impact area more than doubled. While noise may have had an effect on these trends, other factors such as housing quality, business opportunity, and direction of metropolitan growth, should also be considered.

Trends in housing units follow approximately the same direction as population growth. However, the vacancy statistics do not correlate with population growth or to noise impact. Within the noise-impacted area, zones of moderate-noise impact have higher vacancy rates than zones of high impact. Within the SMSA, the vacancy levels are higher in the area of total impact, although the rate of population growth is double that for the metropolitan area.

An explanation for the inconsistency in vacancy rates may be that the areas of moderate impact are more attractive to developers than areas of high impact. Areas of moderate impact may, therefore, be more susceptible to overbuilding and subject to market fluctuations. At the same time, residents in high-noise impact areas may not be able to afford replacement housing in a more desirable area. This problem would be compounded by the lack of new buyers or renters interested in the high-impact area.

Business and Employment

Table 2.4 illustrates the trends in businesses and employment opportunities between 1970 and 1975, for the Atlanta SMSA, the counties in the noise-impacted area, and the noise-impact zones. Based on these figures, the number of businesses in the total noise-impact area have increased by 820, or 30 per cent, as compared to the Atlanta SMSA with an increase of 7,500, or 20 per cent. However, the number of jobs in the total noise-impact area have increased only 13 per cent as compared to 14 per cent for the SMSA, and approximately 40 per cent for Dekalb and Clayton Counties.

Within the area of noise impact, businesses in the moderate-impact zone increased by 500 or 45 per cent. This increase exceeds the growth for the Atlanta Metropolitan Area, Fulton and Dekalb Counties, and is close to the 52 per cent increase in Clayton County. During the same period, however, the number of businesses in the high-noise zone increased by 16 per cent, a rate less than for the SMSA and for Dekalb and Clayton Counties.

Interestingly, the trends for jobs and employment in noise-impacted areas have not been parallel to the trends for businesses. The increase in employment is approximately the same for both high and moderate-impact zones, with increases

Table 2.4. Business and Employment in Noise-Impacted Areas

Area/Noise Zone	Businesses 1970	Businesses 1975	Businesses Change #	Businesses Change %	Employment 1970	Employment 1975	Employment Change #	Employment Change %
Atlanta SMSA	37,340	44,848	7,508	20	623,850	710,900	87,050	14
Fulton County	20,689	21,333	644	3	389,998	388,394	-1,594	- .4
Dekalb County	8,435	11,593	3,158	37	120,638	167,839	47,201	39
Clayton County	1,540	2,339	799	52	24,753	35,116	10,363	42
High-Impact Zone	1,380	1,596	216	16	34,693	39,197	4,504	13
Moderate-Impact Zone	1,330	1,934	604	45	28,278	31,741	3,463	12
Total-Impact Zone	2,710	3,530	820	30	62,971	70,938	7,967	13

Source: Atlanta Regional Commission. 1975 Employment Survey.

of 13 per cent and 12 per cent, respectively. These rates of increase are less than for the SMSA, and Dekalb and Clayton Counties.

Land Use

Table 2.5 illustrates the general land uses within the noise-impact zones, and the total land within the SMSA and the noise-impacted counties. Land use information was not available for the SMSA and the counties, and therefore a comparative analysis is not possible.

The total land areas can be compared with the noise-impacted land uses to illustrate the magnitude of the airport-noise impact. Approximately 7 per cent of the SMSA is within the total noise-impact area, with 5.5 per cent within the moderate-impact zone, and 1.5 per cent in the high-impact zone. The 90,580 acres in the total noise-impact zone almost equal the entire land area for Clayton County (95,360 acres). The usable vacant land (47,658 acres) in the total noise-impact zone is equal to half of the total land in Clayton County, and is 3.5 per cent of all land in the Atlanta SMSA.

Within the noise-impact area, approximately 80 per cent, or just over 72,000 acres, are in the moderate-impact zone. The moderate-impact zone has a larger percentage and quantity of vacant land (40,769 acres; 56 per cent) than the high-impact zone (6,889 acres; 37 per cent). However, the high-impact zone has a higher percentage of residential land use (23 per cent) than the moderate zone (15 per cent).

Table 2.5. Land Use in Noise-Impacted Areas

Area	Land Use										
	Resident		Comm/Ind		Public		Vacant		Vacant Unusable		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Total
Atlanta SMSA											1,313,801
Fulton County											334,829
Dekalb County											171,302
Clayton County											95,360
High-Impact Zone	4,343	23	1,795	10	2,902	16	6,889	37	2,605	14	18,534
Moderate-Impact Zone	10,807	15	2,028	3	6,889	10	40,769	56	11,556	16	72,049
Total-Impact Zone	15,150	17	3,823	4	9,891	11	47,658	52	14,061	16	90,583

Source: Atlanta Regional Commission. Regional Development Plan, Final Small Area Forecast: Land Use, 1975.

The above analysis indicates that the area closest to the airport is more heavily developed, and that a large part of the development is for residential purposes. Relatively large amounts of usable vacant land are available in the areas of moderate-noise impact.

Summary

The operations at Hartsfield International Airport have a significant and extensive effect on the entire Atlanta Metropolitan Area. Using HUD criteria, which is conservative, an area measuring eight by 22 miles is considered "conditionally" acceptable for residential development. Overall, airport noise from Hartsfield International impacts three counties and eight municipalities in the Atlanta Metropolitan Area, covering over 90,000 acres of land.

In spite of noise generated by aircraft overflights, people continue to move into the area. The moderately-impacted area has maintained a level of population growth that is comparable to other parts of the Atlanta area. However, population in high-impact areas has increased significantly less than for adjacent areas, and may soon begin to decline, particularly as land is acquired in Mountain View.

Housing development has followed population growth into the areas defined as having a moderate-noise impact. However, inordinately large vacancy rates persist in these areas, possibly reflecting a combination of the national economy and public concern over aircraft noise. Housing development in areas of high-noise impact is occurring relatively slowly, and can be considered minimal. A particular problem exists with the people presently living in the high-noise-impact area, as many of them cannot afford to move from their present residences into comparable housing in other areas. Their problem is made even more acute with the lack of demand for new or existing housing in the areas of high-noise impact.

Economic development--the growth of businesses and jobs --is progressing at a much slower rate in the noise-impact area than in the rest of the Atlanta Metropolitan Area. This will continue to be a major problem as job opportunities fail to keep pace with the population increases in the area.

In summary, airport noise in Atlanta is a problem which touches almost every aspect of airport community life. Programs that deal with the problem will have to consider:

1. The plight of the people presently residing in areas of high-noise impact.

2. The fact that some people will continue to choose to live in a moderate-noise-impact area, in order to benefit from other features of an otherwise desirable location;

3. The need to encourage economic development that will provide more job opportunities as well as new businesses; and

4. The need to control development within noise-impacted areas. Such controls must restrict the future development of incompatible land use, and insure the rational development of compatible land uses to avoid overbuilding.

CHAPTER THREE

MOUNTAIN VIEW, GEORGIA: A STUDY IN COMMUNITY NOISE IMPACT

The city of Mountain View, Georgia is one of eight municipalities impacted by noise from Hartsfield International Airport. The problem is particularly acute in Mountain View, due to the town's proximity to the airport. The city is immediately adjacent to the airport's eastern boundary, and is so close that the centerline bars of the approach lighting system for Runway 26 are situated in the town's residential areas.

This chapter depicts the existing conditions in the city of Mountain View. The first section provides data which show the general characteristics of the area. The second section of this chapter discusses the extent of the existing noise impact, and some of the programs that are underway to cope with the problem. A summary of the findings and some conclusions are provided in the last section.

Characteristics of Mountain View

Mountain View is an incorporated municipality of Clayton County. Although it is only a small residential community (population 2,127 in 1976), Mountain View has become the focus of considerable study and discussion as a result of the noise problem. This section provides information on the city's basic characteristics, including physical features, population and housing, and land use and property valuation.

Physical Features

Mountain View's general location in the south Atlanta region is illustrated by Figure 3.1. The city is bounded on the north by the City of Atlanta, on the west by Interstate Highway 75, on the south by Interstate Perimeter Highway 285, and on the west by unincorporated Clayton County near Forest Park. Mountain View is divided approximately in half by U. S. Highway 41 which runs north-south through the city. To illustrate the city's close proximity to the airport, U. S. Highway 41 is less than one mile from the end of Runway 8-26, one of Hartsfield's three primary runways. Several residential areas are less than a half-mile from the end of the airport's runways.

The city covers approximately 890 acres, or 1.4 square miles of property. By comparison, Hartsfield International Airport covers over 3,750 acres, or 5.9 square miles. The terrain in Mountain View is rolling or undulating. Highway 41 defines a general ridge line, with the land sloping down to the east and west from the highway. The southwestern corner of the city rises to a peak which overlooks the I-75/I-285 expressway interchange and the southern portion of the airport. The entire area is liberally covered with hardwood and pine forests, particularly in the residential and vacant areas.

Population and Housing

The city is divided into four geographical sectors to help analyze the population and housing in the area.

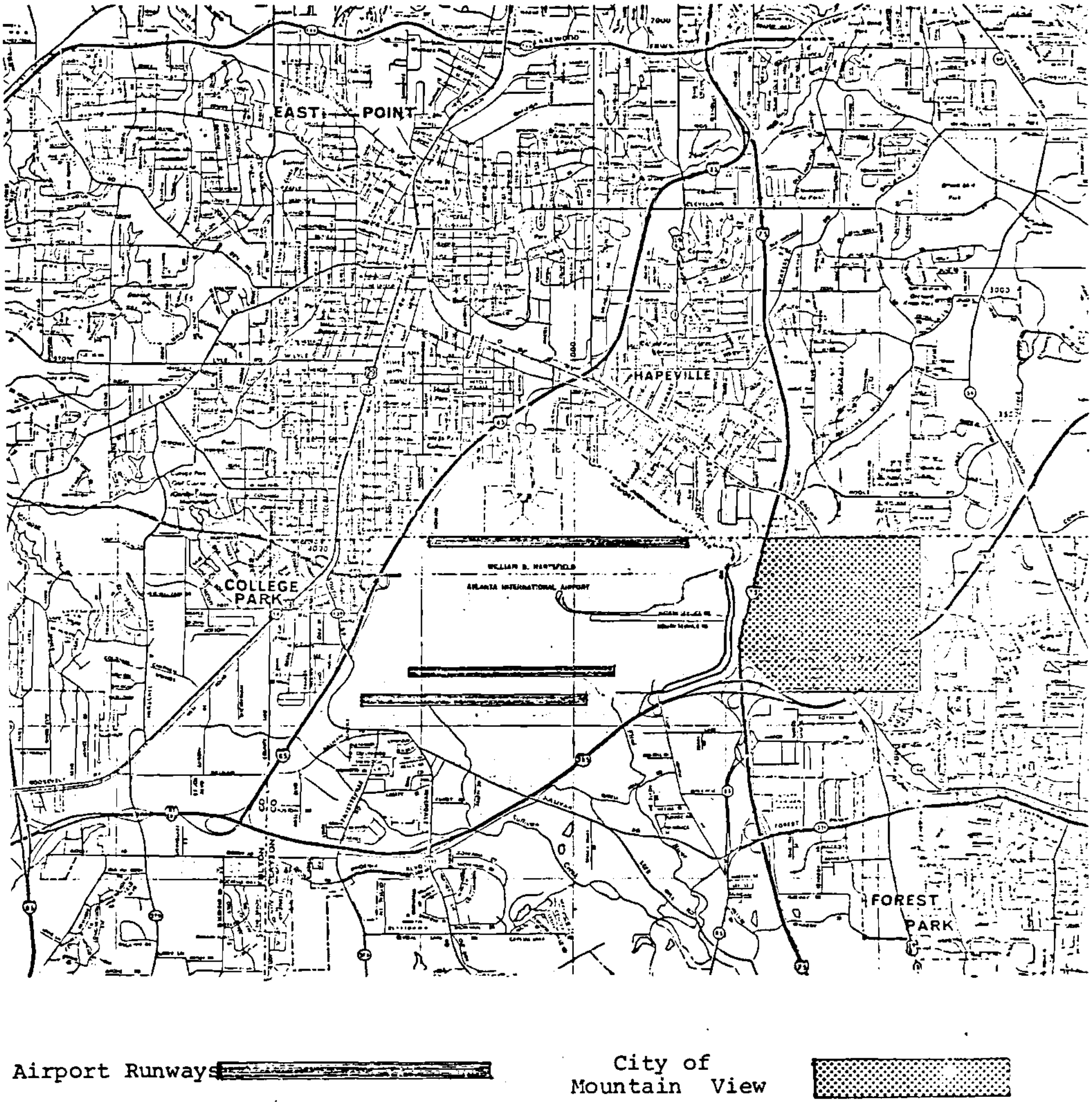
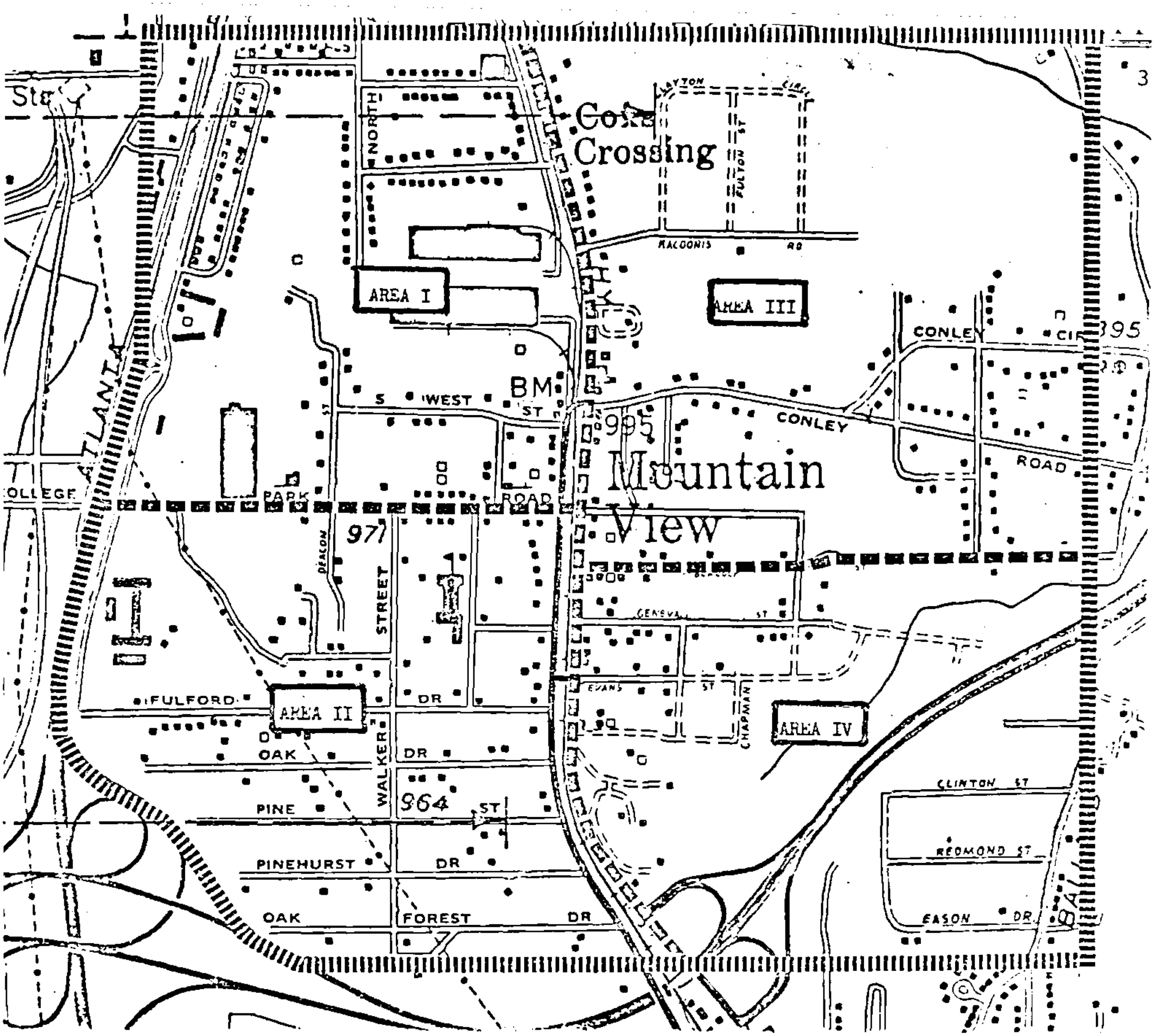


Figure 3.1. Mountain View, Georgia: General Location Map

Figure 3.2 illustrates the sectors, which were defined to correspond as closely as possible to tax map boundaries and census tract blocks.

Table 3.1 provides statistical information on the population and housing in Mountain View. Population figures represent the total number of people residing in the area. "Occupied housing" represents permanent residences, and is divided to show the renter-owner distribution. "Units lacking plumbing" indicates those residences that do not have all three specified plumbing facilities; that is, hot and cold piped water, flush toilet, and bathtub or shower inside the structure. "Units with more than 1.01 person per room" indicates those units with more than one person per room. Rooms are defined as bedrooms, living and dining rooms, kitchens, finished recreation rooms, and family rooms. More than one person per room is generally an indication of overcrowded housing conditions.[8] "Average house value" is the average estimated value for each owner-occupied house, based upon the owners' personal appraisal. While this statistic is not entirely accurate, it should provide an indication of relative housing value.

The population of the entire municipality of Mountain View was recorded as 2,310 in 1960, 2,320 in 1970, and 2,167 in 1975. The average annual net loss in population between 1970 and 1975 was a 30/year, for a 6.6 per cent loss in population over the five-year period.[9] Approximately 63 per



Study Area Boundary (Typical for all Figures)

Sector Boundary

Runway Centerline Extended 5,000 feet

Figure 3.2. City of Mountain View

Table 3.1. Population and Housing in Mountain View

Sector of City	Population #	Population % City Total	% Black Population	Occupied Housing Rent #	Occupied Housing Rent %	Occupied Housing Own #	Occupied Housing Own %	Occupied Housing Total	Total Lacking Plumbing #	Total Lacking Plumbing %	Units with 1.01+ persons/room #	Units with 1.01+ persons/room %	Average House Value
I (NW)	598	23	43	76	43	101	57	177	56	32	35	20	$11,300
II (SW)	1,044	40	1	75	29	188	71	263	2	1	47	18	15,500
III (NE)	424	16	1	44	36	79	64	123	3	2	8	7	16,400
IV (SE)	561	21	2	45	25	132	75	177	2	1	16	9	14,400
Total City	2,627			240	32	500	68	740	63	9	106	14	$14,500

Source: U. S. Bureau of the Census, Block Statistics: Atlanta Urbanized Area. 1970.

cent of the population resides in the western half of the city.

Within Mountain View, sector I has a high concentration of substandard housing. Approximately 32 per cent of the housing units in section I do not have complete plumbing facilities, and 20 per cent of the units have more than one person per room. This area also has the largest percentage of black population (43 per cent). Section II, which has the largest percentage of the city's population (40 per cent), has somewhat better housing conditions with only one per cent of the units lacking complete plumbing facilities. However, the percentage of units with more than one person per room (18 per cent) is almost equal to sector I. Housing conditions in sectors III and IV are considerably better, with relatively lower percentages of units reporting incomplete plumbing facilities or overcrowding. The average housing values for sections I and II are lower than for sectors III and IV, further indicating the difference in housing in the two areas.

Land Use and Property Valuation

Figure 3.3 illustrates the general land use in Mountain View. The map shows areas of residential, commercial, industrial, public (schools, parks, municipal buildings), semi-public (churches), and utility land uses. Land uses were determined by a windshield survey conducted July, 1977. Clayton County tax maps, updated through December, 1975, were used in conducting the land use survey.

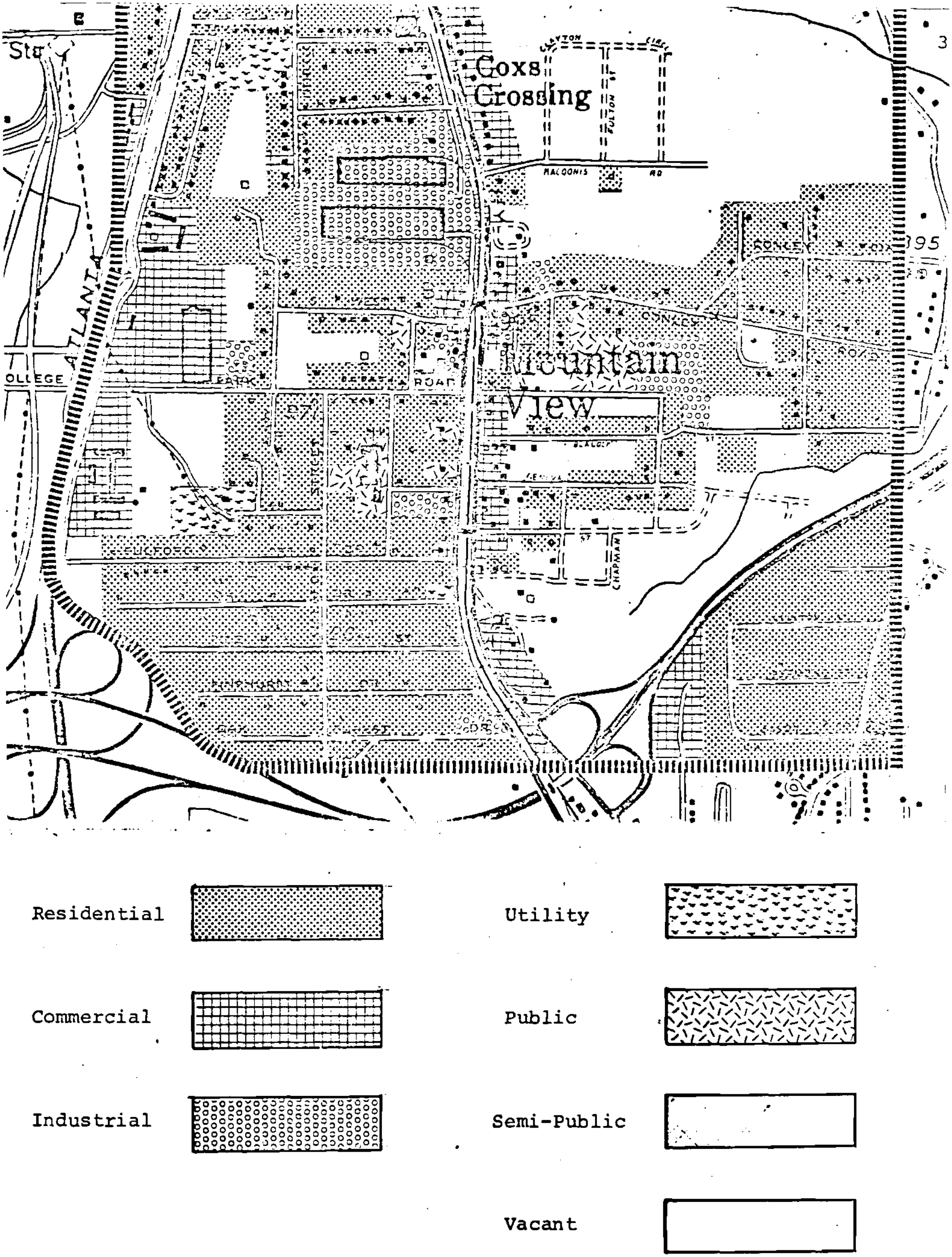


Figure 3.3. Existing Land Use in Mountain View

The land use map illustrates several significant points. The various land uses are dispersed fairly widely throughout the city, particularly in the western half. Several instances of incompatible land uses are found, such as commercial and industrial areas directly abutting residential areas. In one block (bounded by West Street, College Park Drive, and Highway 41), residential, commercial, industrial, and semi-public land uses are clustered together. Small commercial and industrial establishments are located throughout the city in the middle of residential neighborhoods. Vacant land is distributed primarily in the eastern half of the city, with relatively little underdeveloped property in the western half.

The approximate property valuation for the city is shown in Table 3.2. The statistics for the tax base are compiled by sector as described by Figure 3.2. Based on the figures in Table 3.2, most of Mountain View's property value is concentrated in the western half of the city. The western half accounts for approximately 81 per cent of the city's commercial property value, 88 per cent of the residential property value, and 85 per cent of the total city property value.

Not surprisingly, the distribution of the city's property tax base corresponds to the intensity of land use illustrated by Figure 3.3. Higher density residential areas, and extensive commercial and industrial development contribute to the high proportion of the tax base in the eastern section

Table 3.2. Mountain View Property Valuation

Area	Total Assessed Value: Residential Value	%	Comm/Indus/Other Value	%	Total	% Total City Value
Sector I	$4,818,000	48	$5,308,000	52	$10,126,000	39
Sector II	9,492,000	78	2,738,000	22	12,230,000	47
Sector III	1,111,000	42	1,515,000	58	2,626,000	10
Sector IV	868,000	70	382,000	30	1,250,000	4
Total City Value	16,289,000	62	9,943,000	38	26,232,000	100

Source: Clayton County Tax File Update Report. July 24, 1976.

Note: Figures reflect adjustment of tax roll values to account for undervaluation of 30 per cent. Recent acquisitions in the area indicate that the units are consistently under-assessed by about 30 per cent.[10]

of the city.

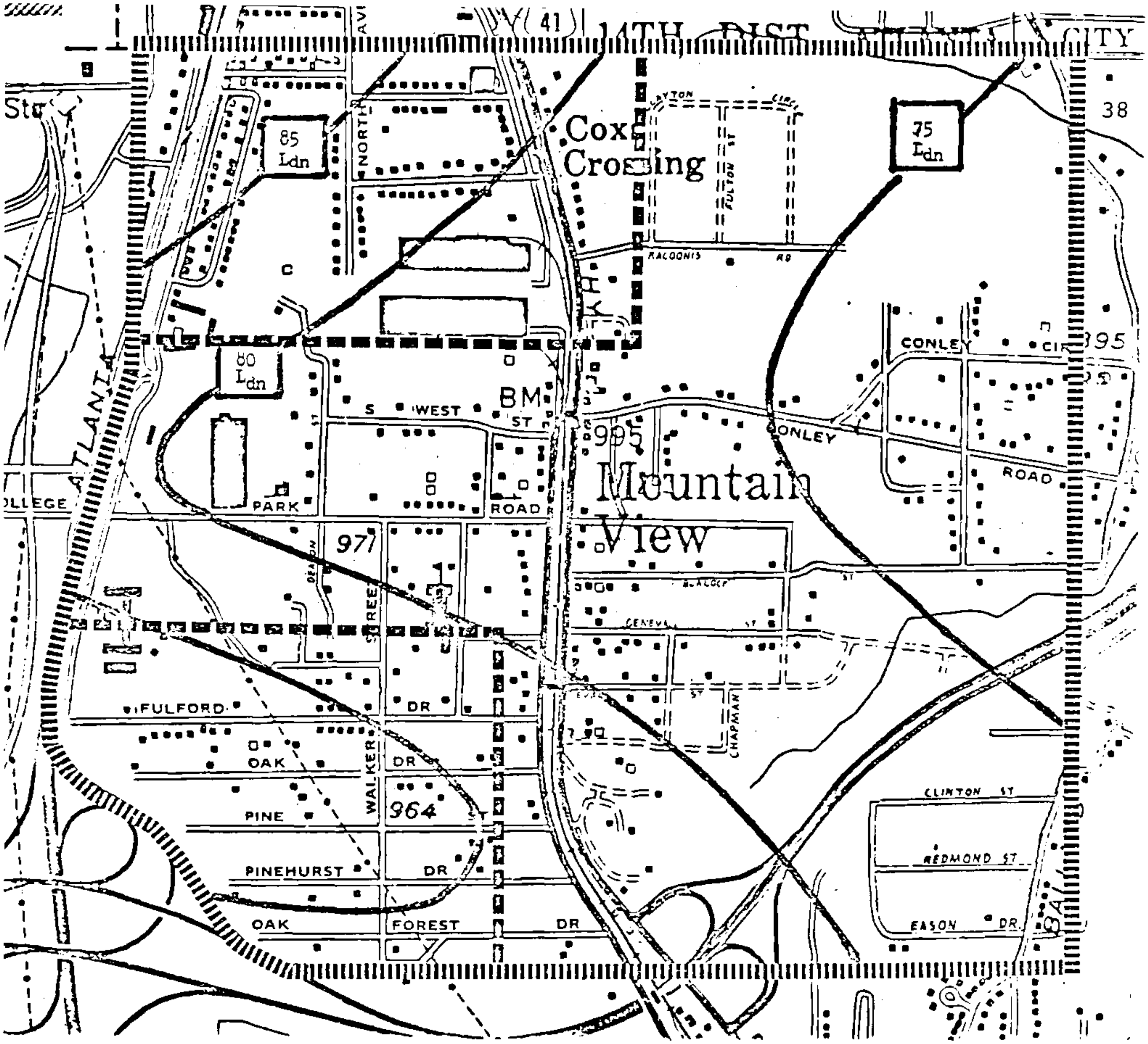
Airport Noise Impact on the Mountain View Community

Noise from Hartsfield Airport is a part of the daily life of every citizen of Mountain View. The effects of this noise have greatly influenced the development of the city. The programs which are being developed to deal with the noise problem may have an even greater effect. This section discusses the extent of the airport noise problem in Mountain View, and illustrates some of the impacts which may result from one of the present noise-abatement programs.

Airport Noise in Mountain View

Figure 3.4 illustrates the approximate L_{dn} noise levels in Mountain View. The contours shown on the map are derived from the EPA noise study discussed in the previous chapter. The map also illustrates the location of the 2500 x 500 foot approach zones for the runways in Hartsfield Airport. The significance of the approach zones will be discussed in the last part of this section.

Analysis of Figure 3.4 indicates that the entire western half of the city is within the "high-impact noise zone" (area exposed to noise levels of 75 L_{dn}+) discussed in the previous chapter. Most of the eastern half of the city is in the same zone, with the exception of the residential area on Conley Road and Conley Circle. However, it should be noted that the contours shown are only approximations. Therefore, it is reasonable to assume that the entire municipality of



Safety Zone Boundary

Noise Level Contour with L_{dn} Rating

Figure 3.4. Noise Level Contours and Runway Safety Zones in Mountain View

Mountain View is exposed to noise levels of at least 75 L_{dn}. Furthermore, a considerable portion of the town is exposed to noise levels of 85 L_{dn} and above.

To illustrate the significance of these noise levels, HUD criteria discussed previously specifies that areas within 75 L_{dn} and above are unsuitable for housing, and that EPA guidelines recommend against residential development in areas of 55 L_{dn} and above. EPA studies have also developed guidelines for maximum noise levels that can be maintained in an area, and assure the public health and welfare. As stated in the EPA study:

> EPA has determined that for purposes of hearing conservation alone, a level which is protective of that segment of the population at or below the 96th percentile will protect virtually the entire population. This level has been calculated to be an Leq of 70 dB over a 24-hour day (based upon a 40-year exposure).[11]

By using a factor of 5 dB to equate L_{dn} with Leq,[12] an individual would have to constantly experience noise levels no greater than 75 L_{dn} to be reasonably assured of avoiding hearing loss due to environmental noise. Assume that a residential structure provides 15 dB difference between interior and exterior noise. An occupant in a house exposed to environmental noise levels of 85 L_{dn} would then be subjected to interior noise levels of at least 70 L_{dn}. As shown on Figure 3.4, several residential communities in Mountain View are in such areas.

Although noise levels below 70 Leq or 75 L_{dn} have not been proven to cause permanent physiological or psychological damage, annoyance has been determined to be correlated with such lesser levels of noise. One study has shown that in areas exposed to noise levels of 75 L_{dn} and greater, approximately 75 per cent of the people in the area were disturbed by the noise. Such exterior noise levels were reported to interfere with TV sound and picture, cause the house to vibrate, and interfere with conversation.[13] Again, it should be noted that almost all of Mountain View is within a noise zone of 75 L_{dn} and greater.

The citizens of Mountain View have not ignored the noise problem in their community. As the problem has advanced, the citizens have become more involved in seeking relief. At one point, angry citizens flew balloons into the aircraft approach zones in protest of the noise problem.[19]

Noise Impact on House Values

Some of the comparisons noted in the previous sections of this chapter indicate the possibility that noise affects the market value of property. A study was commissioned by the City of Atlanta to explore such relationships for the City of Mountain View.[15]

The first step in the study was the identification of other neighborhoods in the general area which were similar to those in Mountain View, except for the variable of noise exposure. Figure 3.5 illustrates the location of two communities in Forest Park, and one in north Jonesboro, which were

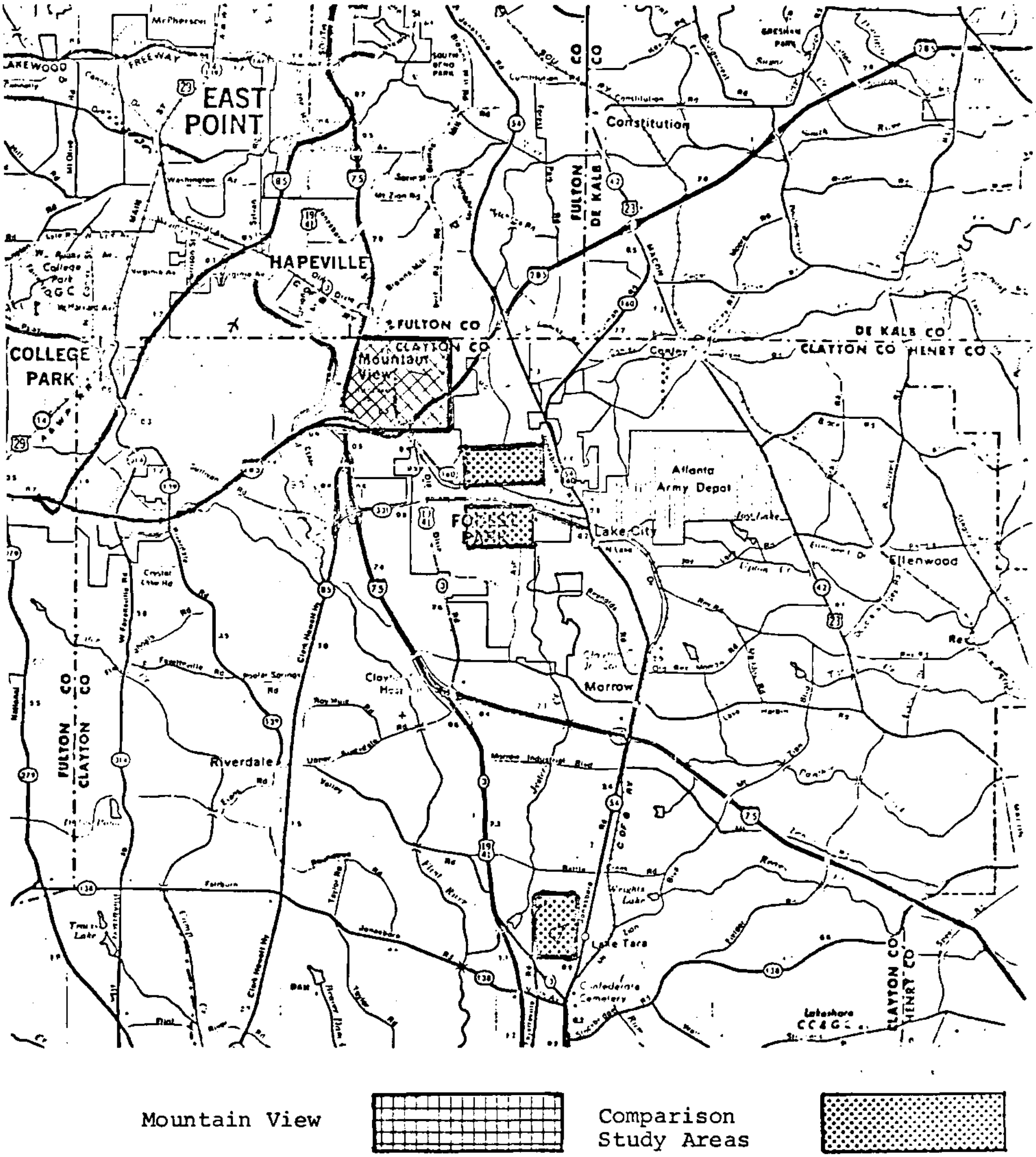


Figure 3.5. Relative Locations of Areas Used for House Value Study

used as comparison communities. The communities were similar to the Mountain View area, except for the level of noise exposure. This ranged from no airport noise at the Jonesboro site, to little exposure at the southern Forest Park site, and moderate exposure at the northern Forest Park site. Figure 3.6 shows the location of the Mountain View sample sites.

Data on home sales in each of the four areas were collected. From this listing, 60 individual home sales were selected using random sampling procedures. The final sample group offered a cross-sampling of the following characteristics:

--Airport noise exposure forecast (using NEF contours)

--Size of structure

--Date of sale

--Age at time of sale

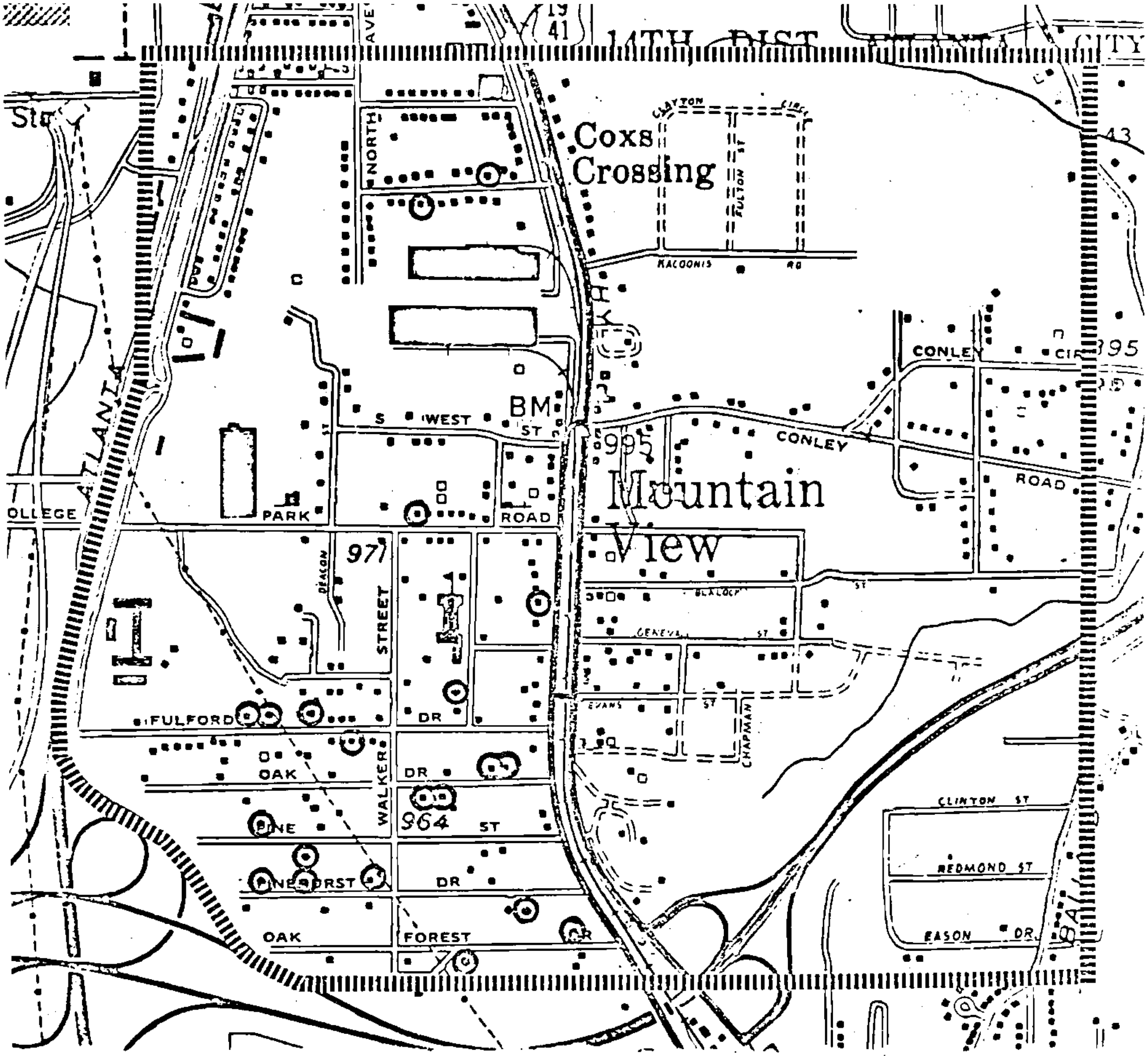
--Number of rooms

--Number of baths

The results of this analysis provide substantial evidence that noise is a factor in determining market value of a residential structure. Although the statistical model cannot be used in other areas, the study illustrates the possibility of evaluating aircraft noise impact with statistical economic data.[16] This concept will be explored in later chapters of this report.

The Mountain View Relocation Project

The City of Atlanta has undertaken a program of relocating residents of the City of Mountain View that presently live



Sample Site Location

Figure 3.6. Sample Sites in Mountain View for House Value Study

in the approach zones of the airport's three runways.[17] As previously noted, Figure 3.4 illustrates the boundaries of the approach zones, which measure 2,500 x 5,000 feet. The zones are centered on the extended centerline of the runway, with the 5,000-foot dimension parallel to the centerline. The zone begins from a point 200 feet from the end of the runway.

The official purpose of the program is to purchase residential property within the approach zones. The program is funded by Federal (75 per cent) and local (25 per cent) funds, under the Airport Development Aid Program. The City of Atlanta project is organized into four phases. The first three phases address only residential property within the approach zones. The fourth phase provides for the procurement of the balance of the residential property west of Highway 41, when criteria are developed. Previous phases of the program are based upon specified safety areas which must be protected from improper development. The fourth phase, however provides for the purchase of "noise impacted" property, thereby requiring some means of defining noise impact.

The relocation project is being undertaken at a considerable cost. A summary of the direct costs and some of the other effects is as follows:[18]

--Acquisition costs (includes legal fees and administration costs as well as procurement cost)

-Phase I (currently underway)	$5,600,000
-Phase II	2,000.000
-Phase III (includes the purchase of Mountain View Elementary School and the Baptist Church)	6,700,000

-Phase IV (noise impacted areas only)	2,200,000
Total Direct Project Cost	$16,500,000

--Total Population Relocated 1,642

--Total Housing Units Purchased 440

--Total Property Value Removed from Local Tax Rolls $14,310,000

Perhaps more significant, is what will be left of the City of Mountain View when the entire project is completed. The city's population will be reduced by more than 75 per cent from 2,167 in 1975, to approximately 525. The number of houses will be reduced from a total of 740 in 1970, to 300 units, a loss of almost 60 per cent. The property tax base for the city will be reduced from $26,232,000 in 1976 to approximately $12,000,000, a loss of 55 per cent.

Summary

It is interesting to note that the areas of Mountain View with the highest levels of noise impact are also the most densely populated. Furthermore, these areas have the poorest and most crowded housing. The area is largely developed, with far less vacant land than in other sections of the city. This has resulted in a concentration of most of the city's tax base in a highly unstable and transitional area.

One possible theory which may explain the unbalanced, not to mention irrational, development in Mountain View may be related to the economic impact of aircraft noise. Possibly, airport noise impact was recognized several years ago when the land was undeveloped and the problems of airport noise poorly defined. The land may have been recognized as undesirable for the higher quality markets and the sales price for the raw land reduced accordingly. Such inexpensive land may have attracted developers who sought maximum profit by building at high densities and aiming at a moderate income market. Initial buyers into the developed area may have been unaware of the problem which either existed or was sure to develop.

The City of Atlanta is attempting to deal with the problem of noise in Mountain View initially through acquisition of the most severely impacted areas. Although the early stages of this program have been successful, many problems remain and some new ones will develop. One major problem will be determining a satisfactory criteria for selecting noise-impacted areas for future procurement projects. Plans which help ease the noise problem in areas that do not warrant or qualify for procurement, must be developed. Finally, the disposition and reuse of the property that is purchased under the acquisition program poses a substantial problem. This is particularly important in the case of Mountain View, as one of the conditions for the approval of the project by the Clayton County Commission was that the property would be returned to the County tax rolls. These problems remain among the most pressing in the area of airport noise control. Some concepts and ideas for their solution are discussed in the following chapters.

CHAPTER FOUR

STANDARDS FOR EVALUATING AIRPORT LAND USE

The previous chapters have established the degree of noise impact in Mountain View and identified the affected population and activities. With those steps completed, the next problem is to determine what changes must be made to help reduce or eliminate the unsatisfactory situations which exist. That step requires a system of criteria to identify the areas of incompatible land use and determine which uses must be removed or changed.

The risk of people on the ground being involved in an aircraft accident is a topic which has been largely overshadowed by the more obvious noise problem. However, the risk that areas around airports are exposed to is an important factor that should be considered in evaluating airport land use. If the hazards of being near an airport can be quantified, steps can be taken to reduce the risk of locating different types of land use in such areas.

This chapter discusses some of the standards that are available for analyzing noise impact. The first section provides a survey of the land use compatibility guides that are presently in use. The second section illustrates a method of evaluating the potential hazard of aircraft accidents.

Survey of Land Use Compatibility Guidelines

This section describes three of the current criteria presently being used to evaluate noise impact on land use and certain types of activities. The first criteria evaluated are the recently-published EPA criteria for noise levels that must be maintained to insure the public health and welfare. The next HUD criteria relate to permitted land uses in different noise zones. Finally, the guidelines proposed to be used by the FAA for airport noise-abatement programs are discussed.

Noise Levels Required to Protect the Public Health and Welfare

The U. S. Environmental Protection Agency was taked by Congress in the Noise Control Act of 1972 to publish criteria for noise levels which would insure the public health and welfare with an adequate margin of safety.[19] The results of this study are the criteria shown in Figure 4.1. Briefly summarized, this criteria requires a maximum 24-hour average sound energy level ($L_{eq(24)}$) of 70 dB in all areas, to protect against hearing loss. Outdoor residential areas should be exposed to noise levels no greater than 55 L_{dn}. Indoor residential spaces and activity areas (such as schools) should be exposed to levels no greater than 45 L_{dn}. Adherence to these criteria would insure against hearing loss, averaged over a 40-year period, and would avoid annoyance and interference with indoor and outdoor activity.[20]

The criteria published by EPA illustrate the maximum noise reduction necessary to achieve an ideal noise environment.

YEARLY AVERAGE* EQUIVALENT SOUND LEVELS IDENTIFIED AS REQUISITE TO PROTECT THE PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

	Measure	Indoor Activity Interference	Indoor Hearing Loss Consideration	To Protect Against Both Effects (b)	Outdoor Activity Interference	Outdoor Hearing Loss Consideration	To Protect Against Both Effects (b)
Residential with Outside Space and Farm Residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with No Outside Space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70	(a)			
Industrial	$L_{eq(24)}$(d)	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	$L_{eq(24)}$	45		45	55		55
	$L_{eq(24)}$(d)		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farm Land and General Unpopulated Land	$L_{eq(24)}$				(a)	70	70(c)

Code:

a. Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity. (See Figure D-2 for noise levels as a function of distance which allow satisfactory communication.)
b. Based on lowest level.
c. Based only on hearing loss.
d. An $L_{eq(8)}$ of 75 dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than an L_{eq} of 60 dB.

Note: Explanation of identified level for hearing loss: The exposure period which results in hearing loss at the identified level is a period of 40 years.

*Refers to energy rather than arithmetic averages.

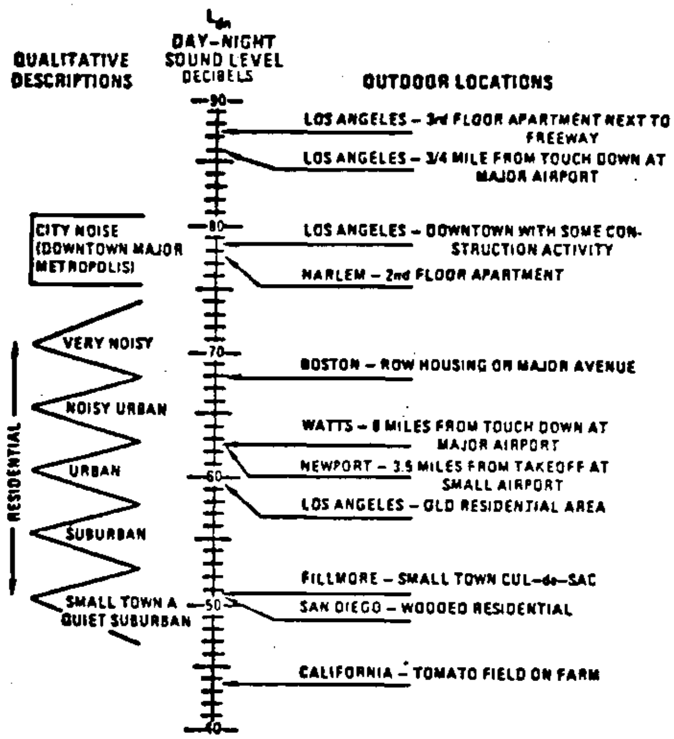
Figure 4.1. Environmental Protection Agency Sound Level Criteria

Source: U. S. EPA Information on Levels of Noise Requisite to Protect Public Health and Welfare. March, 1974.

Any reduction beyond these levels will not result in a substantial improvement to a given situation. A margin of safety is included within the criteria and is the result of conservative analysis of the different noise data.

Since the EPA criteria represent the ideal situation, they are extremely conservative. This is particularly evident when the EPA criteria are compared with typical noise environments, as illustrated by Figure 4.2. Generally, the EPA criteria would result in environmental noise levels no greater than the quietest existing surroundings. As noted by Figure 4.2, the noise levels in many existing outdoor and indoor environments exceed the proposed EPA standards.

The EPA standards are discussed here only to establish a base from which to evaluate other criteria. It is unreasonable to expect that the EPA standards could be achieved in present commercial airport environments, due to the massive land acquisition and relocation programs which would have to be undertaken. Even if the interior noise standards are achieved through sound-proofing programs, the exterior noise level of L_{dn} 55 dB can only be achieved at great distances from an airport. As noted in Chapter III, the area covered by noise zone 60 L_{dn} (the lowest level measured) covers approximately 128 square miles. Therefore, the EPA standards should be considered as ultimate goals and not as absolute measures for short-term planning.



Outdoor Day-Night Sound Level in dB (re 20 micropascals) at Various Locations'

EQUIVALENT SOUND LEVELS IN DECIBELS NORMALLY OCCURRING INSIDE VARIOUS PLACES[6]

SPACE	L_{eq}(+)
Small Store (1-5 clerks)	60
Large Store (more than 5 clerks)	65
Small Office (1-2 desks)	58
Medium Office (3-10 desks)	63
Large Office (more than 10 desks)	67
Miscellaneous Business	63
Residences	
Typical movement of people—no TV or radio	40-45
Speech at 10 feet, normal voice	55
TV listening at 10 feet, no other activity	55-60
Stereo music	50-70

(+) These measurements were taken over durations typical of the operation of these facilities.

Figure 4.2. Noise Levels in Typical Environments

Source: U. S. EPA, op. cit.

Land Use Compatibility Guidelines for Aircraft Noise Environments

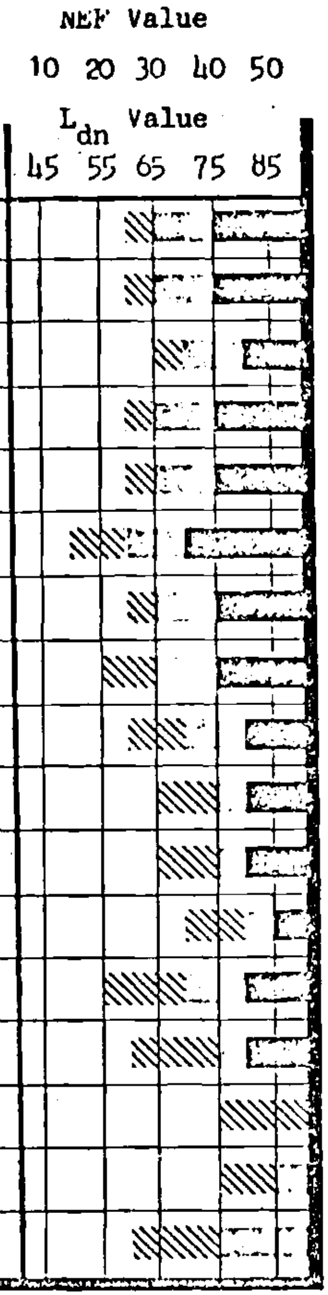
The U. S. Departments of Housing and Urban Development (HUD) and Transportation (DOT) conducted a joint study to determine strategies to deal with airport noise impact. The study, titled Metropolitan Aircraft Noise Abatement Policy Studies (MANAPS) was based upon the situations at four major U. S. airports. The results of the MANAPS study were reduced into a manual published by HUD in November, 1972.[21]

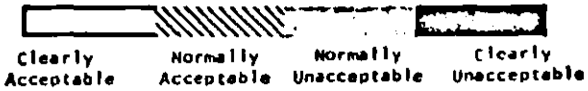
One proudct of the HUD manual is a matrix which illustrates a methodology for defining noise impacts, using the Noise Exposure Forecast (NEF) as the descriptor. Figure 4.3 illustrates the compatibility guidelines and the description of the sensitivity and use factors. The matrix has been annotated to show L_{dn} values as well as the NEF levels. These conversions are approximate, as previously discussed in Chapter II.

The compatibility guidelines shown in Figure 4.3 include a range for the relative impact of various levels of noise on individual land uses and activities. This range of values, referred to as the "Land Use Interpretation for NEF Value" varies from "Clearly Acceptable", through "Normally Acceptable/Unacceptable"to "Clearly Unacceptable". The matrix also includes an evaluation of the noise sensitivity of the various land uses, by rating the approximate NEF values above which new construction or development is not desirable.[22]

LAND USE COMPATIBILITY GUIDELINES FOR AIRCRAFT NOISE ENVIRONMENTS

LAND USE CATEGORY	SLUCM[1] CODE	NSC[2]
Residential - Single Family, Duplex, Mobile Homes	11x[3]	1
Residential - Multiple Family, Dormitories, etc.	11x, 12, 13, 19	1
Transient Lodging	15	2
School classrooms, Libraries, Churches	68 7111	1
Hospitals, Nursing Homes	651	1
Auditoriums, Concert Halls, Music Shells	721	1
Sports Arenas, Outdoor Spectator Sports	722	1
Playgrounds, Neighborhood Parks	761, 762	1
Golf Courses, Riding Stables, Water Rec., Cemeteries	741x, 743x, 744	2
Office Buildings, Personal, Business and Professional	61, 62, 63, 69, 65[4]	3
Commercial - Retail, Movie Theaters, Restaurants	53, 54, 56, 57, 59	3
Commercial - Wholesale, Some Retail, Ind., Mfg., Util.	51, 52, 64, 2, 3, 4	4
Manufacturing, Communications (Noise Sensitive)	35, 47	2
Livestock Farming, Animal Breeding	815, 816, 817	3
Agriculture (except Livestock), Mining, Fishing	81, 82, 83, 84,85,91,93	5
Public Right-of-Way	45	5
Extensive Natural Recreation Areas	91, 92, 93, 99,7491,75	3





Clearly acceptable: The noise exposure is such that the activities associated with the land use may be carried out with essentially no interference from aircraft noise. (Residential areas: both indoor and outdoor noise environments are pleasant.)

Normally acceptable: The noise exposure is great enough to be of some concern, but common building constructions will make the indoor environment acceptable, even for sleeping quarters. (Residential areas: the outdoor environment will be reasonably pleasant for recreation and play.)

Normally unacceptable: The noise exposure is significantly more severe so that unusual and costly building constructions are necessary to ensure adequate performance of activities. (Residential areas: barriers must be erected between the site and prominent noise sources to make the outdoor environment tolerable.)

Clearly unacceptable: The noise exposure at the site is so severe that construction costs to make the indoor environment acceptable for performance of activities would be prohibitive. (Residential areas: the outdoor environment would be intolerable for normal residential use.)

Noise Sensitivity Code	Approximate Noise Exposure Forecast Value Where New Construction or Development Is Not Desirable
1	30
2	35
3	40
4	45
5	50-55

Figure 4.3. Land Use Compatibility Guidelines
Source: U. S. Dept. of HUD, Aircraft Noise Impact. November, 1972.

The recommendations of the compatibility matrix are based upon several factors, including:

--Speech communication needs;

--Subjective judgments of noise acceptability;

--Need for freedom from noise intrusions;

--Sleep sensitivity criteria;

--Case histories of noise complaints near airports; and

--Typical noise insulation provided by common building construction.

The values of the matrix can be adjusted, considering:

--Previous community experience;

--Local building construction, particularly as influenced by climate considerations;

--Existing noise environment due to other noise sources; and

--Time period of land use activities.[23]

The HUD criteria has been adopted by various government agencies for use in evaluating airport noise impact. The Department of Defense has incorporated these standards in the management and planning of their aviation activities.[24]

Airport Noise Control and Environs Compatibility Planning Criteria

The Airport and Airway Development Act provides for Federal assistance to airport sponsors for environmental assessment, land use planning, and financial analysis.[25] Funds for master planning of airports are also included in this program. One element of airport master planning is "Airport Noise Control and Environs Compatibility Planning" (ANCEC), which focuses upon achieving a reduction of airport noise impact on the surrounding environment.

ANCEC planning includes various alternative airport development schemes, operational procedures, air traffic procedures, and revision to existing land uses. The criteria used to guide the program are as follows:

--Confine severe aircraft noise exposure levels (75 L_{dn}) around airports to the area included within the airport boundary; and

--Confine to the extent possible the areas receiving noise exposure levels of 65 L_{dn} to the airport boundary or to lands which are, or can be, reasonably used for activities compatible with such noise levels.

These criteria essentially require airport operators to confine levels of severe noise (interpreted to be 75 L_{dn} or greater) to the area under airport control. This may be achieved through a combination of any number of techniques over the noise source, path, and receiver. It is not limited strictly to land use programs. The criteria further recommends that the area of noise impact defined by 65-75 L_{dn} either be controlled by the airport, or be used by activities compatible with those noise levels.[26]

These criteria represent a major step in the process of encouraging effective noise abatement planning by airport operations. Prior to the establishment of these standards, all ADAP programs concerning land acquisition were justified under safety-oriented criteria. By specifying the 75 and 65 L_{dn} guidelines, airport sponsors can now pursue programs that provide federal funding for "environmentally impacted" problem areas.

It should be noted that the criteria discussed above are levels that define problem areas which are allowed for federal funding consideration. It is not mandated that these areas be brought under the recommended controls. Therefore, local authorities and airport operators are allowed the freedom and flexibility to assess each situation. This is particularly significant because, as noted in Chapter III, the 75 L_{dn} noise zone for Hartsfield International encompasses several municipalities, including 56,000 people and 23,000 residences. The obvious problem which now faces airport managers is the task of developing a balanced noise-abatement program which provides relief for the noise sufferers, allows optim airfield operations, and is economically practical.

Accident Potential Analysis

Advances in aircraft technology and strict operational guidelines have made air travel one of the safest possible means of transportation. However, aircraft accidents do occur, and the reality of such an event must be considered in the planning of airports and their environs. Land use planning must consider crash hazards and can provide an effective means of dealing with the problem.

This section discusses the quantification and analysis of aircraft crash hazards. Some of the background and basic considerations regarding aircraft safety and accident potential are first illustrated, followed by an outline of a methodology for evaluating the crash potential around an airport. The section concludes with a summary of recommended policies to consider in planning for the possibility of an aircraft crash near an airport.

Background

Aviation and airport operations have maintained an excellent record of practicing safety and preventing accidents. When compared with other hazards of the urban environment, the danger from airplane accidents is extremely low. The approximate annual risk rate of death resulting from automobile accidents is about 26.6 per 100,000 population; from work accidents, 19 per 100,000; and from home accidents, approximately 14 per 100,000. In contrast, the risk of death from an airplane crash (for a person on the ground) is less than .5 per 100,000 population.[27]

Commercial aviation has maintained a passenger safety record second only to rail travel. The trend of aircraft accidents has been improving steadily over the history of aviation. However, aircraft accidents continue to occur and most of them happen either during the approach or landing operation. The number of fatal approach-and-landing accidents in the U. S. has remained at between two and six per year for the past 25 years.[28]

It is no coincidence that most aircraft accidents occur during the approach or landing operation. It is at these points that the greatest demands are placed upon the performance of the aircraft and its pilot. The problems of landing are often compounded by inclement weather conditions that are only encountered at lower elevations. Aircraft engines and structural systems are under their greatest stress during takeoff, when maximum power is applied to lift the craft into the air.[29]

Planners responsible for airports and the surrounding area should be aware of the potential for aircraft crashes for obvious reasons. While the risk of involvement in a crash is implicitly accepted by those who choose to fly, the general public may be less aware of the potential hazard in the vicinity of airports. The planner must be able to evaluate the hazards and the risks affecting the airport area, to properly guide its growth and development.

Methodology

Planning for potential aircraft crashes requires decisions to be made based upon the degree of risk that is faced in an area. The same criteria used to evaluate the risk due to natural hazards such as floods and earthquakes can be applied to air crashes. The basic criteria that must be measured are magnitude, frequency, and location. Once these have been quantified, risk can be evaluated to determine the relative safety or danger that must be considered.[30] Some techniques for conducting such an analysis are discussed below. It should be noted that the descriptions and analyses that follow are concerned only with the hazard to people and activities on the ground. The discussions do not include allowances for hazard and risk for passengers or crewmembers of an aircraft involved in an accident.

Accident Frequency. Frequency refers to the number of times an event occurs during a certain period of time. Generally, frequency is inversely related to magnitude for natural hazards and for aircraft accidents. In other words, the less the probability of an event happening, the greater its severity when it does occur.[31]

The two factors that determine the frequency of events such as aircraft accidents are the accident rate and the number of events subject to an incident during a given period of time. In evaluating the potential for aircraft crashes, this means comparing the accident rate with the number of annual flight operations.[32]

Many factors enter into determining an accident rate, including weather conditions, type of aircraft, operating procedures around the airport, and pilot experience. Generally, it is difficult to develop accurate accident rates for an airport from experience at that single location, due to the limited statistics generally available for analysis. Atlanta's airport, for example, has never suffered a fatal aircraft accident. This does not mean, however, that there is no risk of such an accident at that site.

For general planning purposes, the use of a gross accident rate is adequate for risk decision-making. One rate that has been used is the occurrence of 1.38 accidents per million operations, for all civil aircraft activity. This converts to one accident per 725,000 operations. Although this figure may not be accurate for a specific airport, it should illustrate the approximate accident frequency for airports in general.[33]

The period of recurrence of an aircraft accident can be calculated by dividing the number of operations per potential accident (725,000) by the number of annual operations from a runway or an airport. For Hartsfield Airport, with approximately 490,000 operations in 1976, this would result in an accident recurrence interval of about 1.5 years (725,000 ÷ 490,000 = 1.47). Assuming equal distribution of these operations among the three parallel runways, Mountain View would be exposed to the following accident recurrence intervals:

Northwest Mountain View:

$$\frac{\text{725,000 operations per accident}}{\text{82,000 operations for R/W 26 L}} = 8.8 \text{ years}$$

Southwest Mountain View:

$$\frac{\text{725,000 operations per accident}}{\text{164,000 operations for R/W 27 R and L}} = 4.5 \text{ years}$$

Again, it should be noted that the number of operations per accident may not be accurate for this particular application. Furthermore, the assumption that the annual operations are evenly distributed may not be valid. However, the analysis does indicate that the potential for an aircraft accident on or near the Atlanta airport is a near-term possibility.

Location of Aircraft Accidents. As previously mentioned, most aircraft accidents occur on or near the airport during takeoff or landing operations. Data collected by the National Transportation Safety Board on civil aircraft accidents in California over a nine-year period indicated that approximately 72 per cent of the accidents occurred on the airport or within one mile of the runway. Figure 4.4 illustrates the results of that study and shows that a significant difference in accident frequency occurs at 1/4 mile from the end of the runway.[34]

Based upon the study discussed above, an area one mile from the end of a runway is determined to include most of the area subject to aircraft accidents (75 per cent). This area may be broken into two segments to identify the high accident potential area within 1/4 mile of the end of the runway. The width of the accident potential area has been established to be 1,500 feet, or 750 feet each side of the extended runway centerline. This dimension is based upon aircraft behavior as the result of pi,ot error or mechanical failure during takeoff and landing.[35] It should be noted that this defines the area subject to the point of impact of an aircraft accident. It does not consider the effects of debris and wreckage that may be scattered from a crash.

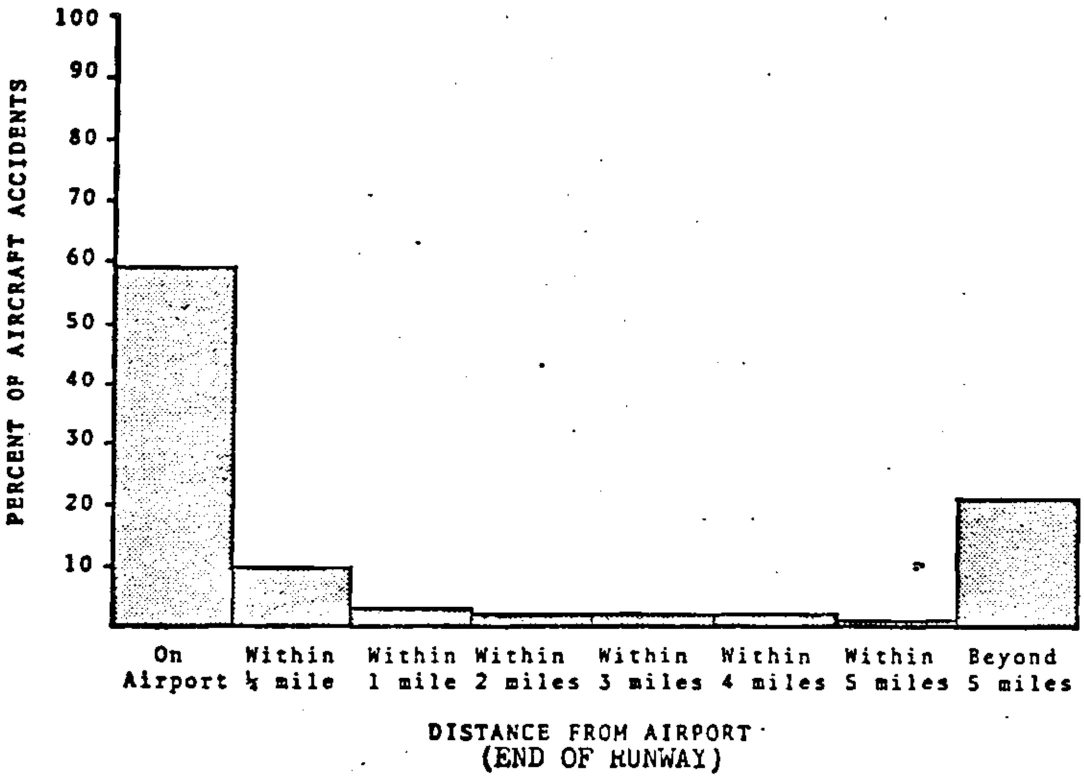


Figure 4.4. History of Civil Aviation Accidents in California, 1964-1973

Source: Envicom Corp. <u>Draft Airport Study</u>. June, 1976.

Accident Magnitude. The magnitude of an air crash varies greatly with the size, weight, and speed of the aircraft. Density of people on the ground and type of structures impacted are also a factor.

For this study primary concern of crash magnitude is the potential danger to the inhabitants of a residential area. Studies have been conducted that have developed factors and formulas for evaluating such impact. The basic equation for evaluating crash impact, as determined by those studies, is:

$$I = K\ W\ D$$

where:

I = impact of crash, in non-occupant deaths;

K - a constant determined from historical crashes. For this analysis, K = .0015, based upon aircraft crashes into residential areas at: Kenner, Louisiana in 1967, involving a DC-8; at Albany, New York in 1972 with a commuter aircraft; and at Chicago, Illinois in 1972, with a Boeing 737.

W = weight of aircraft in thousands of pounds, and

D = population density, in persons per acre, at the crash site.

Application of these formulas to the Mountain View area (population density, four persons per acre) results in the following figures:

Assume the crash of a 350,000-pound DC-8;

I = .0015 x 350 x 4 = 2.1 possible deaths.

Assume the crash of a 170,000-pound Boeing 727;

I = .0015 x 170 x 4 = 1 possible death.

Assume the crash of a 775,000-pound Boeing 747;

I = .0015 x 775 x 4 = 4.7 possible deaths.

A moral question arises regarding the "acceptable" level of deaths that should be allowed in a given situation. An assumption of any level except "no deaths" indicates that a proposal is willing to compromise a human life, for some gain. In accident-potential areas, the issue becomes significant in choosing the types of land use that will be permitted to develop and expose the occupants to the risk of being killed in an airplane accident.

A study conducted for Alameda Airport in Oakland, California, proposed that establishing a probability of death that is less than .5 will result in odds that are greater that no one would be killed in the event of an accident. Therefore, the study recommended that a "ceiling" of .49 should be established for evaluating the land uses surrounding an airport to determine if population densities would result in "acceptable" levels of risk.[37]

By establishing the acceptable level of deaths at .49, the equation for evaluating crash impact can be solved for either maximum weight of aircraft permitted to operate over an area, or the maximum density of population that should be exposed to the crash hazard. At Hartsfield International, it is unreasonable to expect that aircraft size could be effectively controlled. The alternative, then, is to specify the maximum density of population for the potentially-impacted area. This is determined below for Mountain View, assuming a worst case situation involving a Boeing 747:

$$I = .49 = .0015 \times 775 \times \text{Maximum Density}$$

$$\text{Maximum Density} = \frac{.49 \quad .49}{.0015 = 775} = .42 \text{ persons per acre.}$$

Therefore, in areas exposed to the possible crash of a Boeing 747, the maximum average population for the area should not exceed approximately .5 persons per acre. Presently, Mountain View has a population density of about two persons per acre.

Crash Hazard Analysis and Policy Development

Public policies must be developed that effectively control growth around an airport. Such policies can be influenced by the studies of accident potential that have been discussed. By establishing the frequency at which accidents may occur, the problem is confirmed as a reality. The location in which accidents may be expected to occur defines the area that must receive the closest attention. Developing the magnitude of a potential accident illustrates the intensity of development and habitation that can be tolerated and still protect the public.

Government controls and regulations can be used to implement the recommendations developed from an analysis of aircraft accident potential. Flight paths can be adjusted to remove the possibility of an aircraft crash from a sensitive area. Where new construction is planned, runway orientation can be adjusted within the tolerances dictated by wind conditions. Zoning regulations can restrict the development of land uses that will introduce excessive numbers of people into accident-hazard areas.

Summary

A broad range of criteria and guidelines have been developed for evaluating noise impact on a community. The EPA health-related criteria provide some long-term goals that should be pursued, but are unreasonably low for immediate application. The land use guides that are presently in use allow considerable flexibility on the part of the planner. The federal funding that is being made available and the liberal limits specified for permitted application should encourage considerable activity in developing noise-abatement projects. Hopefully, some of the data from these projects can be used to develop better compatibility guidelines and noise criteria.

The quantification and consideration of aircraft crash hazard is a topic that is still discussed in very guarded terms in many aviation circles. Open discussion of airplane crashes and the damage they impose have not been encouraged. However, the figures developed by even a crude analysis of crash hazard must be considered.

The severe damage and the loss of life that follows an airplane crash have been well established. Responsible officials must insure that every possible step has been taken to reduce the risk of damage and destruction associated with aviation accidents. The procedures described in this analysis should be of some benefit in helping continue that effort.

CHAPTER FIVE

ECONOMIC IMPACT OF NOISE

Economic analysis offers a potential method for evaluating noise in uniform and universally accepted terms. While noise impact may be highly subjective, economic impact is generally expressed in very definitive terms. People may not understand the scientific aspects of noise, but they are usually very familiar with subjects such as property values.

Noise is difficult to evaluate in economic terms, as there are no effects that remain for analysis after a noise source is quieted.[38] Available data on noise and its impact are generally rudimentary and do not lend themselves to economic analysis. Most cost data have been developed as estimated percentages or components of other costs. Many other costs are expressed in terms of orders of magnitude or, in some cases, as educated guesses.[39]

This chapter explores the recent attempts that have been made to define noise in economic terms. The first section of this chapter discusses the studies that have been conducted on the economics of noise impact as it affects individual airports and their surrounding communities. The second section describes the efforts that have been undertaken to analyze the economic impacts of noise as it affects the complete system of aviation and the air travel system.

Economic Analysis at the Local Level

Economic analysis of noise on individual communities has been limited to quantifying the costs of its impact. The benefits of noise abatement have been generally stated only as a reduction of the costs and do not quantify items such as "improved environment" or "reduced annoyance". The local costs of airport noise that have been studies can be grouped into four basic categories: property devaluation; costs for noise easements; damage awards as a result of litigation; and costs to insulate the receiver from the noise source. Each of these is discussed briefly below.

Property Devaluation due to Noise Impact

There has been significant controversy over the impact of noise on the market value of land, particularly for residential property. As illustrated in Chapter Three, a study has shown noise to be one of the most important determinants of house value in Mountain View. However, studies have not supported this hypothesis in all airport communities.

One study of the Los Angeles area attempted to determine the decrease in the rate of appreciation of property because of jet noise. Out of eight sample areas, the rate of appreciation for four areas impacted by airport noise was not significantly different from the rate for homes in the areas unaffected by the noise.[40] Another analysis of a subdivision in Rosedale, Long Island, indicated little or no effect on house value due to airport noise. The subdivision, located in close proximity to Kennedy International Airport, sold out at established market prices, in spite of the apparent noise situation.[41]

In contrast, the results of several other studies have established that noise may be a factor in determining house value. Mention has already been made of the study of the Mountain View area, where noise exposure was second only to house size in determining market value. In another case, an analysis of land sales adjacent to the San Francisco airport indicated that property value was significantly affected by noise.[42]

Property valuation is not related just to noise. Several other factors, such as the market demand for real estate, and the availability of property, will have a significant effect on price. The intended use of the property will also influence the value of land on the market.

A study of the Washington, D. C. area estimated the reduction of property values in that city to be about .5 per cent for each unit of L_{dn} above a base level of 55 L_{dn}. While this figure was determined to be the most accurate, other studies were noted that have proposed between .4 and 1.6 per cent reduction in value per unit of L_{dn}. Assuming a depreciation of .5 per cent per unit of L_{dn}, a house that would normally be appraised at $50,000 with no depreciation for noise, would be reduced in value by about $2,500 if located in an area exposed to noise levels of 55 L_{dn}. The same house, in a 75 L_{dn} noise zone, would be reduced in value by about $5,000 due to noise exposure. Figure 5.1 illustrates a summary of the estimated impact of noise exposure on property values, as presented in the Washington, D. C. study.[43]

The variety of information from the different studies precludes considering the results of any single report as a firm data source. However, the trends of the separate analyses indicate the need to pursue study of this area further. The following comment probably provides the best estimate of the present situation:

> It is unlikely that property values reflect all of the benefits of pollution abatement. In the opinion of most urban or environmental economists, the real estate market reflects the more tangible aspects of pollution...The subtle, more insidious long-term health effects of pollution are likely to escape consumer notice and will not be reflected in market values. As a consesequence, property damage estimates must be supplemented with additional damage information....[44]

Costs for Noise Easements

The purchase of "flyover" easements has been used as a method of compensating property owners for the theoretical loss in value resulting from airport operations. Through easements, property owners may be allowed to retain title to their property and use the land within the restrictions of the easement. A summary of the cost for flyover easements at five different airports is shown in Figure 5.2. As

Summary of Aircraft Noise Pollution Studies

Study	Functional Form for Noise	Noise Coefficient	R^2	Best Marginal Damage Est.	Range of Noise Values	Percent Reduction in Average Property Value per Unit NEF
Emerson[a]	Log	-0.001	0.79	-5105/NEF	100-125 CNR	0.6
Paik[b]	Log	-.60 to -.76	0.76	-5455/NEF	20- 40 NEF	1.6
Dygert[c]	Semi-Log	-0.005 to -0.007	0.60	-5140/NEF	25- 45 NEF	0.5
Price[d]	Linear	-1.207	0.50	-5100/NEF	25- 45 NEF	0.4

[a]For CNR 110-115. Emerson estimates damages at $42/CNR for a $20,000 home in 1967. Expanding this figure by a factor of 1.50 to convert to NEF yields 513/NEF. This damage was then expanded by 1.40 for a $26,000 home and by 1.20 to convert to 1970 dollars.

[b]Paik estimates the mean elasticity for all three airports combined to be -0.65. For NEF 40, a unit change amounts to 2.50 percent or about a 1.62 percentage reduction in property value. For a $28,000 home, this amount to $454/NEF.

[c]Estimated for a 0.5 percent reduction in property value for a $28,000 home.

Figure 5.1. Estimated Impact of Noise Exposure on Property Values

Source: Jon P. Nelson, The Effects of Mobile Source Air and Noise Pollution on Residential Property Values.

City	Number of Easements	Maximum Paid	Minimum Paid	Range	Average
Columbus, Ohio	30	$6,670	$ 870	$5,800	$2,414
Denver, Colorado	32	1,751	931	820	1,000
Des Moines, Iowa	--	2,000	1,200	800	--
Seattle, Washington	--	--	--	--	4,200
Jacksonville, Florida	--	9,000	250	8,750	4,625

Figure 5.2. Cost of Flyover Easements at Five Airports

Source: U. S. EPA, The Economic Impact of Noise.

illustrated, flyover easements may range from $1,000 to more than $4,600. The method of assessing the value of the easements will vary between cities. In Seattle, easements were acquired at a cost equal to the price differential between the affected property and similar property removed from the airport noise. Under this method, easements cost approximately 15 to 20 per cent of fair market value.[45]

Easements are a potentially useful tool in helping alleviate the noise problem and should be considered as part of a noise-abatement strategy. The statistics noted in Figure 5.2 may provide some guideline for estimating approximate cost of flyover easements. However, the broad range in the compensation paid among the five cities illustrates the need to assess each situation independently.

Damage Awards Resulting from Litigation

The damages that the courts have awarded for the "taking" of property by aircraft operations are often considered an indicator of the cost of airport noise. The 1962 case of Griggs v. Allegheny set the precedent that the rights of airport neighbors were being taken by airport operations.[46] In 1970, the California Superior Court ruled in favor of the plaintiffs in Aaron v. City, in awarding damages to more than 600 homeowners in the vicinity of Los Angeles Airport.[47] Figure 5.3 illustrates the distribution of the damages claimed, which totalled more than $2,000,000,000. At the present time,

Litigant	Number of Households	Total Damage Claimed	Range	Average Damages per Household
Individuals	30	$ 3,342,725	$ 1,148,950	$ 111,428
Groups of Individuals	594	11,189,000	3,928,000	18,837
Organizations	61,212	2,800,000,000	2,300,000,000	45,743

Note: Some of the cases are still pending.

Figure 5.3. Summary of Litigation Against Los Angeles International Airport

more than $45,000,000 of these claims are still outstanding, pending court rulings.[48]

While court litigation may be an indicator of activity or unrest around an airport, it may not represent actual costs that can be attributed to noise. This is illustrated in the disparity between the amount claimed in the Los Angeles case and the amount still under judicial consideration. Presently, the courts are trying to develop an equitable method of assigning such damages. In most cases, actual damages awarded are determined by subjective appraisal of individual properties, as opposed to applying a uniform standard of evaluation.[49]

Insulating the Receiver from the Noise Source

Insulating an individual or activity from noise can be accomplished in two ways: the receiver can be removed an adequate distance away from the noise, or the receiver can be protected by soundproofing at a given location. The cost of both of these methods is a direct cost of noise abatement and is easily quantified. The problem of evaluating such costs is in determining the degree of protection that is necessary.

The cost of providing a "noise right-of-way" around an airport is the sum of the costs to purchase the land and the costs to relocate the original owners. As previously noted, a land acquisition for Mountain View will cost approximately $16 million. The program will result in the acquisition of over 400 housing units on 450 acres of land and the relocation of more than 1,600 people. In Los Angeles, a similar program will cost $300 million to acquire almost 2,000 homes located on 400 acres of land. Obviously, the cost for such a program will depend upon the conditions at each site and will generally be a function of population density and property value. It should be noted that these figures do not consider any subsequent impact that may result from the relocation of the displaced families. If programs of this type were undertaken on a broad scale, the impact on the housing market and other aspects of the economy would be significant.[50]

Several studies have been conducted to evaluate the feasibility of soundproofing houses located in noise-impacted areas. Two of the more prominent studies were those conducted by Bolt, Beranek, and Newman and by Wyle Laboratories. The results of these two studies are discussed briefly below. All cost estimates are in 1977 dollars.

The Bolt Beranek and Newman Study. The BBN study was conducted for Los Angeles International Airport and produced cost estimates to soundproof a 1,000-square foot home. The objective of the study was to determine the costs to reduce aircraft noise within a typical house to imperceptible levels. The study was based upon hypothetical conditions and the use of theoretically-proven soundproofing techniques. There was no field application of the proposed techniques to verify either building cost or actual noise reduction.

The results of the BBN study are illustrated in Figure 5.4. The noise reduction noted is in addition to the

Bolt Beranek and Newman's Estimate of the Probable Range of Modification Costs for a 1,000-Square Foot House, 1966

(Exclusive of Costs for Ventilation)

House Type	Noise Insulation Improvement: 5-10 PNdB	10-15 PNdB	15-20 PNdB
Light Exterior Walls (wood, metal, stucco, or composition)	\$510 to \$1,615	\$3,150 to \$4,725	\$7,880 to \$8,865
Heavy Exterior Walls (brick, masonry, or concrete block)	\$510 to \$1,615	\$3,150 to \$4,725	\$5,515 to \$6,700

Cost Estimates for Installation of House Air Conditioning for a 1,000-Square Foot House

Type of System	Approximate Installation Costs
Room Units	\$985 - \$1,180
Central-Utilizing Existing Ducting	\$988 - \$1,775
Central - New Ducting Required	\$2,365 - \$3,150

Figure 5.4. Costs for Soundproofing Residential Structures

Source: U. S. EPA, Economic Impact of Noise.

approximately 15 dB protection afforded by a standard housing unit in good condition.

The Wyle Laboratories Study. Wyle Laboratories also conducted a study of the cost to soundproof houses in the Los Angeles area from airplane noise. However, a major difference between the two studies is that actual existing houses were soundproofed as necessary to attain certain levels of noise reduction. Therefore, the Wyle study provides estimates that have been verified through actual field application.[52]

The Wyle project provided soundproofing in each house to achieve one of three different degrees or "stages" of noise reduction. The objectives of the three stages were as follows:[53]

1. Stage One provided the minimal amount of insulation. Basically, stage one homes were modified to provide the owners with the option of living with doors and windows closed. This required the installation of forced air ventilation systems and minor modifications to doors and windows.

2. Stage Two required the modifications provided by stage one, plus major improvements to exterior doors and windows and beamed ceilings.

3. Stage Three provided all of the improvements in stages one and two plus a complete modification of the roof and ceiling systems, floors, and walls.

Actual costs for the modifications and the target level of noise reduction were as follows:[54]

Stage One: $5,457 per house, or $3.57 per square foot of floor area, to achieve a noise reduction of 25 dB SIL.

Stage Two: \$8,194 per house, or \$5.36 per square foot of floor area, to achieve a noise reduction of 35 dB SIL.

Stage Three: \$21,335 per house, or \$13.94 per square foot of floor area, to achieve a noise reduction of 45-50 dB SIL.

The SIL descriptor (Speech Interference Level) that was used to gauge the improvements is based upon the arithmetic average of sound pressure levels in the three octave bands centered at 500, 100, and 2,000 hertz. Therefore, SIL cannot be equated directly with PNdB, or the descriptors used in this study such as L_{dn}. Numerically, sounds on the SIL scale are approximately 20 dB less than the value for the same sound expressed in PNdB.[55]

Upon completion of the soundproofing program, a survey was conducted to evaluate the perceived improvement, as rated by the occupants of the test houses. The results of the survey are illustrated in Figure 5.5. A significant conclusion drawn from the survey was that the occupants of homes with the Stage One modifications perceived little, if any, improvement in noise levels. Among the owners of houses with Stage Two and Three modifications, most were satisfied that there had been some improvement in the interior noise levels. However, in those areas where the exterior noise levels warranted the Stage Three improvements, the homeowners considered the outside noise too high to be unsatisfactory for residential use. Therefore, Stage Two appears to be the only realistic degree of soundproofing that should be considered.[56]

		ALL HOUSES				STAGE 2 & 3 HOUSES ONLY			
		Before Modification		After Modification		Before Modification		After Modification	
		Yes	No	Yes	No	Yes	No	Yes	No
	Do the aircraft ever...								
A	Startle you?	24	15	10	27	17	10	7	20
B	Keep you from going to sleep?	19	20	14	23	12	15	7	20
C	Wake you up?	26	13	16	21	20	7	11	16
D	Intefere with listening to TV or radio?	37	2	19	18	26	1	13	14
E	Make the TV picture flicker?	29	10	21	16	19	8	14	13
F	Make the house vibrate or shake?	36	3	28	9	27	0	23	4
G	Interfere with conversation?	38	1	17	20	27	0	12	15
H	Disturb your rest or relaxation?	30	9	11	26	20	7	6	21
I	Interfere with or disturb any other activity? IF YES, SPECIFY ONE ONLY	28	11	8	29	17	10	5	22
J	Bother, annoy or disturb you in any other way? IF YES, SPECIFY ONE ONLY	15	24	6	31	12	15	5	22

Table C-1 - Comparison of Before-Soundproofing and After-Soundproofing Responses to Questions on Specific Activities Interfered With.

Figure 5.5. Results of Post-Soundproofing Survey, Los Angeles County

Source: Wyle Corp. Final Report on the Home Soundproofing Project. March, 1970.

In summary, both the BBN study and the Wyle Laboratories Project indicate that some degree of soundproofing is a feasible alternative for reducing aircraft noise impact. However, the economic or practical feasibility will depend upon the degree of soundproofing required. Also, an obvious shortcoming of soundproofing is that it has no effect on exterior noise levels. Therefore, no amount of soundproofing can fully solve a noise problem where outdoor noise levels must also be reduced.[57]

Economic Analysis at the System Level

The most significant contributions to improving the airport noise situation have been the efforts to develop quieter aircraft. The programs currently underway have been generated as the result of Federal Aviation Regulation, Part 36, of December, 1969 which imposed noise limits on new types of commercial aircraft. These regulations were amended in 1973 to impose the same limits on newly-produced aircraft, regardless of their date of certification. The result of these regulations has been a steady reduction in noise levels at airports as the new, quieter jets come into operation.[58]

The DOT-NASA Study

The programs generated by the U. S. Department of Transportation and NASA to develop a quieter aircraft have included an economic analysis of the various alternatives. The analysis is based upon the development of a model, or "fictitious" airport, with operations representing the present and planned air travel demands. Development and operating costs were then assembled and compared with the anticipated benefits from the program.

The elements of the program are as follows:

(1) Implement a Two-Segment Approach. Require aircraft to follow an approach into an airport by first using a 6° glide slope to an intercept point and then follow a 3° glide slope to landing. This would be in comparison to a 3° glide slope for the entire approach, as is now general practice. It should be noted that this system will have little effect on the 75 L_{dn} area, as most aircraft are on the 3° segment before the 75 L_{dn} contour closes.

(2) Retro-fit JT8D and JT3D Engines with Acoustically-Treated Nacelles. The study assumes that all civilian aircraft could be retro-fitted with the quiet nacelles by the end of 1978.

(3) Retro-fit JT8D Engines with Modified Fan Systems (REFAN) and Retro-Fit JT3D Engines with Acoustically-Treated Nacelles. The study assumes that all civilian-powered aircraft could be modified by the end of 1981.

These three elements were selected as the optimum alternatives from a number of different choices using the engine types and modifications noted above. The program was evaluated through an analysis of the investment and operating costs for each element, the reduction in NEF/L_{dn} levels, and the percentage of noise-impacted population which experience reduced noise levels.[59]

A summary of the program costs is illustrated by Figure 5.6. These costs represent the expense of implementing the elements of the program. Figure 5.6 also shows the long-term costs of the effects of the program after the retro-fitted aircraft are phased out of the fleet. The cost is predicted to be the greatest during the 1980's, when most of the existing aircraft would be put through the refit program. After that time, new and quieter aircraft will begin to replace the older planes with the refit package.

The program benefits are illustrated in Figure 5.6, which shows the reduction in population impacted by airport noise as a result of the program improvements. Figure 5.6 also illustrates the conversion of these benefits to monetary figures, based upon the improved property valuation that results from the reduction in area impacted by airport noise.

A final analysis of the program is illustrated by Figure 5.7. The Cost/Benefit analysis presented by the figure includes different periods of time for evaluation at various opportunity costs or discount rates. Analysis of the Benefit/Cost ratios indicates that the two-segment approach and the combination of the two-segment approach with the engine nacelle treatment are acceptable alternatives.[60]

Impact of the DOT Study on Atlanta

As part of the DOT study, a survey was conducted of 23 airports to determine the effects of the various alternatives on land area and population impacted by different noise levels. Atlanta's Hartsfield International Airport was one of the 23 airports selected for the study. Figure 5.9 illustrates the results of that analysis, as compared with the results for the entire group of 23 airports.[61]

ANNUAL AGGREGATE COSTS DUE TO AIRCRAFT
NOISE ABATEMENT, 1975-1997
(Millions of $)

Year	SAM8D/3D and Two-Seg. Approach	RFN8D/SAM3D and Two-Seg. Approach	Two-Seg. Approach Only
1975	$ 24.1	—	—
1976	154.8	$103.1	$25.0
1977	262.8	179.6	50.0
1978	352.4	456.1	—
1979	24.2	510.1	—
1980	25.3	834.8	—
1981	26.5	1211.5	—
1982	27.7	209.0	—
1983	28.9	218.4	—
1984	28.1	226.4	—
1985	25.1	232.8	—
1986	21.8	239.2	—
1987	17.7	204.8	—
1988	12.8	146.5	—
1989	6.8	82.0	—
1990	2.7	56.3	—
1991	0.6	46.3	—
1992	0.1	45.3	—
1993	—	35.5	—
1994	—	19.2	—
1995	—	10.9	—
1996	—	6.3	—
1997	—	2.2	—

Source: U. S. Department of Transportation, Office of Noise Abatement, unpublished supporting data for Airport Noise Reduction Forecast: Volume 1—Summary Report for 23 Airports (Final Report), DOT-TST-75-3 (Springfield, Virginia: National Technical Information Service, October 1974). These data are summarized in the DOT report on page 4-9.

ANNUAL AGGREGATE COSTS DUE TO AIRCRAFT NOISE ABATEMENT, 1975-1982
(Millions of $)

Abatement Program	Year							
	1975	1976	1977	1978	1979	1980	1981	1982
Two-Seg. Approach								
Investment	—	$ 25.0	$ 50.0	—	—	—	—	—
SAM8D/3D								
Investment	$23.9	$122.9	$197.7	$323.1	—	—	—	—
Lost time	—	4.7	7.1	11.8	—	—	—	—
Op. costs	0.1	1.1	3.5	7.4	10.1	10.6	11.1	11.6
Lost prod.	0.1	1.1	4.5	10.1	14.1	14.7	15.4	16.1
Total	$24.1	$129.8	$212.8	$352.4	$ 24.2	$ 25.3	$ 26.5	$ 27.7
REFAN8D/SAM3D								
Investment	—	$ 71.9	$116.0	$418.2	$450.5	$725.8	$1033.2	—
Lost time	—	4.7	7.1	15.8	8.0	12.0	16.0	—
Op. costs	—	0.5	2.2	7.6	18.7	35.8	60.5	78.1
Lost prod.	—	1.0	4.3	14.3	32.9	61.2	101.8	130.9
Total		$ 78.1	$129.6	$456.1	$510.1	$834.8	$1211.5	$209.0

Figure 5.6. Annual Aggregate Costs for Aircraft Noise Abatement.

Source: Jon P. Nelson, The Effects of Mobile Source Air and Noise Pollution on Residential Property Values. April, 1975.

IMPACT OF AIRCRAFT NOISE ABATEMENT
ON NOISE EXPOSURE, 1972 to 1987

Abatement Program[a]	Year 1972	1975	1978	1981	1987
No Change					
Δ NEF	0.0	-2.1	-2.1	-2.5	-2.4
Eff. (%)	100.0	84.0	72.0	67.0	70.0
Two-Seg. App.					
Δ NEF	0.0	0.0	-0.5	-0.6	-0.6
Eff. (%)	100.0	84.0	61.0	54.0	55.0
SAM3D/8D and Two-Seg. App.					
Δ NEF	0.0	0.0	-2.2	-2.2	-1.9
Eff. (%)	100.0	84.0	45.0	44.0	43.0
RFN8D/SAM3D and Two-Seg. App.					
Δ NEF	0.0	-0.0	-2.2	-5.9	-5.5
Eff. (%)	100.0	84.0	45.0	14.0	16.0

[a]The Δ NEF data were supplied to the author by John E. Wesler, Office of Noise Abatement, U. S. Department of Transportation. The efficiency factor, Eff. (%), is the percentage of 1972 noise-impacted population remaining inside NEF 30 in any given year from U. S. Department of Transportation, Office of Noise Abatement, Airport Noise Reduction Forecast: Volume 1—Summary Report for 23 Airports (Final Report), DOT-TST-75-3 (Springfield, Virginia: National Technical Information Service, October 1974), p. 3-33.

ANNUAL AGGREGATE BENEFITS FROM AIRCRAFT NOISE ABATEMENT, 1975-1997
(Millions of $)

Year	Benefits per person per NEF	Two-Seg. App. Low	Two-Seg. App. High	SAM3D/8D and Two-Seg. App. Low	SAM3D/8D and Two-Seg. App. High	RFN8D/SAM3D and Two-Seg. App. Low	RFN8D/SAM3D and Two-Seg. App. High	No Change Low	No Change High
1975	$ 5.68	$ 3.63	$ 4.33	$16.01	$ 19.06	$16.01	$ 19.06	$ 61.12	$ 72.76
1976	6.08	7.08	9.27	28.97	40.80	28.97	40.80	62.31	77.88
1977	6.51	10.22	14.88	38.01	65.33	38.01	65.53	63.38	83.39
1978	7.00	13.02	21.35	42.27	93.94	42.27	93.94	64.56	89.67
1979	7.49	14.28	24.34	44.90	100.52	54.34	156.72	71.75	102.02
1980	8.01	15.57	27.63	47.68	107.49	55.43	227.60	79.37	115.61
1981	8.57	16.93	31.35	50.60	115.01	43.18	308.43	87.56	130.69
1982	9.00	17.84	32.94	51.74	118.04	45.86	320.07	92.00	136.32
1983	9.45	18.79	34.59	52.87	121.05	48.66	332.04	96.64	142.15
1984	9.92	19.78	36.30	53.97	124.05	51.59	344.31	101.48	148.19
1985	10.42	20.84	38.12	55.10	127.12	54.70	357.22	106.61	154.58
1986	10.94	21.94	40.02	56.19	130.13	57.92	370.37	111.94	161.16
1987	11.49	23.12	42.03	57.26	133.17	61.68	385.49	117.75	168.21
1988	12.06	17.49	31.80	43.27	100.65	46.61	291.32	123.59	176.56
1989	12.66	10.20	18.54	24.48	56.68	27.18	169.80	129.74	185.34
1990	13.29	7.22	13.11	13.14	28.92	19.26	120.37	136.20	194.57
1991	13.95	6.46	11.74	7.70	15.06	17.22	207.64	142.96	204.23
1992	14.65	6.49	11.80	6.99	12.96	17.20	108.14	150.13	214.48
1993	15.38	5.26	9.57	5.26	9.57	14.03	87.72	157.61	225.16
1994	16.15	2.93	5.32	2.93	5.32	7.81	48.76	165.51	236.44
1995	16.96	1.71	3.10	1.71	3.10	4.55	28.45	173.81	248.29
1996	17.81	1.08	1.96	1.08	1.96	2.87	17.93	182.52	260.74
1997	18.70	0.38	0.68	0.38	0.68	1.01	6.27	191.64	273.77

Figure 5.7. Aggregate Benefits and Impact of the Aircraft Noise Abatement Program.

Source: Jon P. Nelson, op. cit.

TOTAL DISCOUNTED NATIONAL COSTS AND BENEFITS
FROM JET AIRCRAFT NOISE ABATEMENT, 1975–1997[a]
(Millions of $)

Scenario	Costs	Benefits Low	Benefits High	High Benefits / Costs
	At a 5% Discount Rate until the Year 1987			
No Change	—	$ 774.2	$1089.0	—
Two-Seg. App.	$ 65.9	137.2	238.6	3.62
SAM3D/8D and Two-Seg. App.	827.8	412.0	881.2	1.06
RFN8D/SAM3D and Two-Seg. App.	3306.8	414.8	1962.5	0.59
	At a 5% Discount Rate until the Year 1997			
No Change	—	$1398.2	$1980.3	—
Two-Seg. App.	$ 65.9	164.1	287.5	4.36
SAM3D/8D and Two-Seg. App.	839.1	462.1	992.3	1.18
RFN8D/SAM3D and Two-Seg. App.	3513.1	486.3	2409.7	0.69
	At a 10% Discount Rate until the Year 1987			
No Change	--	$ 563.2	$ 785.3	—
Two-Seg. App.	$ 58.2	97.0	166.5	2.86
SAM3D/8D and Two-Seg. App.	687.8	297.8	625.4	0.91
RFN8D/SAM3D and Two-Seg. App.	2436.0	300.5	1326.3	0.54
	At a 10% Discount Rate until the Year 1997			
No Change	--	$ 827.0	$1162.6	--
Two-Seg. App.	$ 58.2	109.8	189.7	3.26
SAM3D/8D and Two-Seg. App.	693.5	322.4	680.1	0.98
RFN8D/SAM3D and Two-Seg. App.	2534.9	334.5	1539.0	0.61

Figure 5.8. Benefit-Cost Analysis of Jet Aircraft Noise Abatement.

Source: Jon P. Nelson, *op. cit.*

Impact of NEF Contours for 23 Airports.

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	4794.3	499.2	163.4									
6°/3° Glideslope				3021.6	284.5	70.1	2685.2	275.8	66.6	2719.1	813.5	203.3
6°/3° Glideslope SAM 3D and ED				2249.0	144.8	16.8				2116.0	564.9	159.5
6°/3° Glideslope SAM 3D, REFAN ED							693.1	60.6	3.0	780.4	264.1	69.5

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	1333	226	58									
6°/3° Glideslope				868	157	71	805	147	67	817	335	151
6°/3° Glideslope SAM 3D and ED				640	110	45				642	260	115
6°/3° Glideslope SAM 3D, REFAN ED							305	66	25	337	154	71

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	888	110	34									
6°/3° Glideslope				562	65	19	539	60	16	551	182	65
6°/3° Glideslope SAM 3D and ED				394	38	5				421	134	40
6°/3° Glideslope SAM 3D, REFAN ED							155	16	1	184	62	17

(c) Impacted Land Area Inside Contour - Square Miles

Impact of NEF Contours for Atlanta

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	99.8	27.0	8.7									
6°/3° Glideslope				84.9	19.2	7.1	85.4	19.2	6.5	80.2	39.6	18.7
6°/3° Glideslope SAM 3D and ED				76.7	15.2	0.8				74.3	33.3	18.7
6°/3° Glideslope SAM 3D, REFAN ED							38.2	6.5	0	50.7	25.8	8.6

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	107	19	9									
6°/3° Glideslope				75	13	6	78	13	6	69	28	13
6°/3° Glideslope SAM 3D and ED				63	11	4				60	24	11
6°/3° Glideslope SAM 3D, REFAN ED							28	6	2	34	16	8

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	101	14	4									
6°/3° Glideslope				69	8	2	72	8	2	63	22	8
6°/3° Glideslope SAM 3D and ED				57	6	1				54	18	6
6°/3° Glideslope SAM 3D, REFAN ED							22	2	0	28	11	3

(c) Impacted Land Area Inside Contour - Square Miles

Figure 5.9. Impact of Noise Source Reduction Alternatives on Atlanta and 23 U. S. Airports.

Source: Carroll Bartel, et al., Airport Noise Reduction Forecast, Volume I. October, 1974.

A comparison can be made of how the different elements of the program will affect Atlanta, as compared to the entire 23 airports in the study. As an example, the Atlanta population affected by noise levels of 75 L_{dn} or greater will decrease by 28 per cent in 1978 and 28 per cent in 1981, as a result of the glideslop modification. For all 23 airports studied, however, population affected will decrease by 43 per cent in 1978 and 45 per cent in 1981. If the only improvement implemented is the modified glide slope, by 1987 the population affected will increase by 47 per cent for Atlanta and by 62 per cent for all 23 airports. Therefore, it can be assumed that a modified glide slope would provide relatively less improvement for Atlanta than it would for the 23 airports collectively.

Although the percentage differences for Atlanta and all 23 airports are significant for population affected, the differentials are about equal for land area impacted. This may reflect the differences in land use and residential development around Atlanta, as compared to the total of 23 airports. In fact, a comparison of <u>total</u> land area impacted and <u>developable</u> area impacted indicates that Atlanta has a substantially larger percentage of impacted land that is developable (74 per cent) than do the entire 23 airports collectively (49 per cent).

Summary

In many respects the discussions in this chapter have further established the difficulty of dealing with noise problems. The nebulous nature of noise impact and damage, the lack of data, and the uncoordinated collection of noise information are a restatement of an obvious problem. However, some order is beginning to develop.

Many studies have shown that noise is an economic factor, and as such may potentially be defined in economic terms. The lack of adequate data has hindered the development of principles for evaluating the economic impact of noise. However, this is largely because there has been no organized demand for such information. While data have been difficult to collect in the past, present activity in noise-abatement projects affords considerable opportunity to develop new sources of empirical information.

The costs that have been developed for soundproofing and for development of quieter aircraft provide some information that can be applied to economic analysis. However, the variance of these data between locations requires that individual studies collect information that is accurate for their particular site.

CHAPTER SIX

A STRATEGY FOR DEVELOPING LAND USE PLANS IN AREAS IMPACTED BY AIRPORTS

This chapter proposes an outline for preparing land use plans in areas that are subjected to airport impact. The goal of such a plan is to make a community compatible with the airport environment. The study presented in this chapter does not consider the potential improvements that may be possible through regulating airport operations or by improving aircraft technology. Although such improvements offer considerable promise, a detailed study of their application is beyond the scope of this study.

The strategy that is described in this chapter assumes that a combination of methods is necessary to alleviate problems of airport impact in a community. The most effective method of providing relief is to remove the impact or to remove the receiver from the impacted area. Where removal is not possible or practical, improvements such as soundproofing that adapt the receiver to the environment are the next best alternative. The final, and often least effective alternative, is to provide compensation to the receiver as payment for his suffering or loss of property.

The proposed strategy outlines a series of steps that are designed to help determine the best method of impact abatement for different areas within a community. The first section of the chapter outlines these basic steps and describes the concepts behind each step. The second section illustrates a generalized evaluation of the existing land use in Mountain View, using the strategy described in the first section. The third section provides some conclusions derived from the general analysis of Mountain View.

It is important to note that the objective of this chapter is to illustrate a general methodology and not to provide specific policy recommendations. Data that have been described earlier in the thesis are used for illustration purposes. This qualification is particularly important as it applies to the discussion on Mountain View. The results of that analysis are not intended to be used for basic policy statements or decisions. The studies are based upon assumptions that may not accurately represent the situation in Mountain View. The analysis of Mountain View is used only as a means to illustrate the separate steps of a land use plan for airport-impacted areas.

Description of the Strategy

A strategy for developing land plans for airport-impacted areas should address individual problems in descending order of importance. It should also insure that the final program represents the optimum combination of alternative solutions. The different steps should also provide "tests" at each level of problem evaluation to minimize land acquisition, encourage the conservation of potentially compatible areas, and ensure compatible future development.

The following seven-step procedure describes a recommended strategy for preparing an airport land use program:

(1) Identify the incompatible land uses in the crash hazard zone;

(2) Identify land uses that are exposed to noise levels that may induce occupants' hearing loss and other health problems;

(3) Determine the specific improvements necessary to soundproof all land uses not proposed for acquisition, to reduce the interior noise levels to acceptable limits. Estimate the total cost for these improvements;

(4) Assess the cost of noise easements for areas not subject to acquisition. Include those areas which may qualify for soundproofing;

(5) Estimate the cost to acquire properties where the combined expenses for soundproofing (step 3) and noise easements (step 4) either exceed the fair market value of the property or exceed a specified percentage of the fair market value;

(6) Prepare recommended zoning, building, and housing regulations; and

(7) Prepare a redevelopment plan for areas to be acquired under the program.

Steps one, two, and five identify the minimum area that should be considered for acquisition. Steps three, four, and six determine which areas can be preserved and what must be done to avoid the need for their acquisition. Step seven requires the preparation of a redevelopment plan after all property in the study area has been scheduled either for acquisition or for preservation. A detailed discussion of the concepts behind each of the seven steps is provided below.

Step One: Identification of Incompatible Land Uses in the Potential Zone

Evaluation of the crash hazard zone requires the identification of the probable impact area and an analysis of the existing land uses in the zone. Existing land uses are then compared with the types of use and activity that are recommended for the crash hazard area. The types of land uses permitted in the safety zone will depend upon the number of people that will inhabit the area, in terms of average occupancy per year.[62]

Average occupancy is determined by adjusting population densities in an area for the percentage of time during airport operations that are actually occupied. Average population density can be calculated by the formula:

$$\text{Average Density} = \frac{\text{Total Persons Occupying Area}}{\text{Total Acreage in the Area}} \times \frac{\text{Number of Hours Area is Occupied}}{\text{Total Hours of Airport Operation}}$$

The existing commercial and industrial land uses in the accident potential zone can be evaluated by determining the average population for each separate activity. This analysis can be accomplished by obtaining figures on the number of employees, customers, and visitors that are estimated to be present over a period of time.

It should be noted that many forms of work involve some assumption of risk. The procedure that is illustrated above helps quantify that risk, to allow employers and workers to decide whether or not they wish to be exposed to the hazard. The risk can be compensated by salaries and in premiums paid for insurance and workman's compensation coverage.

The same procedure can be used to evaluate commercial land uses. By defining risk in terms that can be converted to economic costs, such as insurance premiums, the value of the risk can be quantified. This cost information can be incorporated into a market analysis to determine if a site that is exposed to potential crash hazards is economically attractive.

Once the incompatible land uses in an accident-potential zone have been identified, a decision must be made on the disposition of the activities that do not conform to risk limitations. Acquisition is one solution, as little can be done to protect a structure or area from crash damage in the event of an accidnet. Another approach is the use of police power regulations to control population density within the accident-potential zone.

<u>Step Two: Identification of Land Uses Exposed to Extreme Noise Levels</u>

This step has two purposes, the first of which is to identify noise-sensitive land uses in areas where noise levels may cause adverse health effects. The second purpose is to determine where the noise levels are so great that corrective action such as soundproofing is neither possible nor practical. Several of the points to consider in these analyses are described below.

Identification of Land Uses Exposed to Damaging Noise Levels. Noise presents a potential health problem in two ways. One aspect is the hazard of creating a physical disability such as permanent hearing loss. A second health-related problem is the annoyance caused by noise, as it affects emotional or social wellbeing.[63]

In a recent EPA study noise-induced hearing loss was concluded to be the only organic disease that could be directly attributed to noise. In addition to hearing loss, annoyance and other indirect effects can be caused by noise, including interference with speech, sleep, and thought.[64]

As part of the EPA study, a set of guidelines were developed to establish the minimum noise levels necessary to insure protection of the public health and welfare. The elements of that study were discussed in Chapter Four, with the recommended noise levels illustrated by Figure 4.1. As noted by that summary, the EPA guidelines recommended yearly average sound levels of 70 L_{dn} for exterior industrial and commercial spaces; 45 L_{dn} for interior residential areas; and 55 L_{dn} for exterior residential spaces. It should be noted that the

EPA guidelines are not rigid standards by which to evaluate all noise situations. The guidelines establish a "floor", below which there will be little additional protection of the public health and welfare.

A study of land use compatibility around airports prepared for the Department of Housing and Urban Development was also discussed in Chapter Four. The results of that study are illustrated in Figure 4.3. As shown by that illustration, residential uses are noted as clearly unacceptable in areas exposed to noise levels of 75 L_{dn} and greater and are normally unacceptable in areas exposed to noise levels between 65-75L_{dn}. The HUD study also analyzed the effects of noise on the performance of tasks, with the conclusion that noise-induced performance losses are consistently evident in areas exposed to noise levels in excess of 85 L_{dn}[65]

The recommendations of the HUD study are not absolute. The guidelines are based largely on community response predictions based on previous experience at various locations. For specific locations, considerations must also be given to the background noise levels and the social, economic, and political conditions that exist.[66]

Identification of Soundproofing Limitations. As illustrated in Chapter Five, present soundproofing technology can provide noise reductions between exterior and interior spaces of up to 35 L_{dn} for residential structures. The maximum exterior noise level that can be attenuated can be determined by establishing a maximum permitted noise level for interior residential spaces. For instance, if the EPA guideline of 45 L_{dn} for interior residential spaces is selected, the maximum exterior noise level that could be attenuated to that standard would be 80 L_{dn}, assuming noise reduction of 35 dB from soundproofing. This value of noise reduction is based upon the soundproofing studies conducted by Bolt Beranek, and Newman, and by Wyle Laboratories, as discussed in Chapter Five.

Commercial and industrial activities can be planned with much more flexibility through the use of soundproofing than can residential areas. Since most commercial and industrial operations are more tolerant of higher noise levels, soundproofing can make them compatible with high levels of noise exposure. For example, Figure 4.2 in Chapter Four illustrated that the sound level in business spaces is about 68 L_{dn}. Assuming that the building could be soundproofed to provide 30 dB attenuation, the activity could be situated in an area exposed to noise levels in excess of 95 L_{dn}. Therefore, it is generally possible for all but the most noise-sensitive types of commercial and industrial activities to adapt to the airport noise environment.

Step Three: Determination of Soundproofing Requirements

This step in the strategy requires estimating the costs to provide soundproofing for the various land uses and activities located in noise-impact areas. The exceptions to this requirement are those land uses where soundproofing has been determined to be impossible, or where an activity is not compatible with the accident potential in the area. Estimating soundproofing costs for these exceptions is not necessary, as they will probably be part of an acquisition and relocation program.

Soundproofing is only a partial solution to noise problems, as it does not affect the outdoor environment. Though soundproofing may allow flexibility in planning for commercial and industrial areas, its application to residential uses is limited. The best use of soundproofing for residential areas may be in locations where housing demand is great and the cost of not providing housing exceeds the expense of soundproofing.[67]

The soundproofing study conducted by Wyle Laboratories for the City of Los Angeles concluded that acoustical modification of homes around airports is technically feasible and can provide a significant amount of relief to the residents.[68] However, the assessment by the homeowners of the value of the improvements appeared to be directly related to the <u>degree</u> of change which the soundproofing provided. Specifically, improvements which provided only a nominal degree of change were rated as ineffective by the homeowners. An interesting conclusion which came out of the homeowner survey was the rating of outside noise levels by people whose homes were provided with the highest degree of soundproofing. Although these residents considered the soundproofing effective, they rated the exterior spaces as unsuitable for residential use, due to excessive aircraft noise.[69]

The costs to provide different degrees of soundproofing were discussed by the examples noted in Chapter Five. Although these estimated provide guidelines for evaluating approximate costs, they are not applicable to all situations. Many different factors, such as local climate, construction methods and materials, and lifestyle patterns must be considered in preparing a soundproofing program.

Step Four: Assessment of Compensation for Noise-Impacted Areas

The topic of excessive outside noise levels has not been directly addressed up to this point. Exterior noise levels generated by aircraft overflights present a particular problem, as there is no effective way to insulate against them. Furthermore, the exterior noise levels in many areas do not pose a threat to health or welfare, but result in decreased utility of exterior spaces. While the outside noise levels may not warrant relocation to a quieter area, they may deprive individuals of the ability to enjoy an otherwise peaceful atmosphere.

Monetary compensation may provide a possible means to account for the problems generated by outside noise levels. This topic is broached very carefully, as there is considerable opportunity for the abuse and misuse of this technique. The use of compensation implies that a price can be placed on environmental quality and on an individual's right to personal wellbeing. This is not the intention for the proposed use of compensation.

It is possible that the use of both soundproofing and compensation would be appropriate for the same property. This is not necessarily a duplication of payment or effort, as each of the two methods are directed at different impacts. Soundproofing provides improvements to the interior environment of a structure, while compensation for exterior noise levels accounts for the loss of enjoyment of outside spaces.

A major problem with the use of compensation is the difficulty in identifying the effects of noise in economic terms. As noted in the previous chapter, there has been little research into the true economic impact of noise. Therefore, compensation will continue to be based on relatively subjective information.

Monetary payments are not a means of improving environmental conditions. Compensation does not remove noise, but provides economic reward to individuals who allow it to exist. By receiving some form of compensation for unabated noise, people are actually being paid to endure the noise problem.

Compensation should be considered only as a last possible alternative for reducing community unrest due to noise problems. Other techniques such as relocation or soundproofing should be fully explored before compensation is considered as an alternative. Payments should particularly not be used to compensate for conditions that may cuase hazards to health and personal wellbeing.

It is possible that the use of both soundproofing and compensation would be appropriate for the same property. This is not necessarily a duplication of payment or effort, as each of the two methods are directed at different impacts. Soundproofing provides improvements to the interior environment of a structure, while compensation may account for the loss of enjoyment of outside spaces.

A major problem with the use of compensation is the difficulty in identifying the effects of noise in economic terms. As noted in the previous chapter, there has been little research into the true economic impact of noise. Therefore, compensation will continue to be based on relatively subjective information.

Compensation may be paid by a number of means. One technique that is currently being used for the reservation of air rights over approach zones is navigation easements. An easement is a limited right in land owned by another and may be acquired by purchase, lease, gift, agreement, or comdemnation.[70]. Easements could be used to purchase the "right to make noise" over certain property. Another method of compensation is through tax credits, where assessments are reduced on property around airports that are affected by noise. One problem with both easements and tax credits that must be considered is that they provide compensation to property owners, but not to renters.[71]

Step Five: Comparison of Acquisition Costs vs. Costs for Soundproofing and Compensation

At this step the total costs should be evaluated to determine the best alternative between improving a property or acquiring it. The decision may be made to acquire a property even if the sum of the soundproofing and easement costs are less than the market value. Many agencies have established a policy of purchasing property in fee simple if the alternative costs exceed 50 per cent of the market value.[72] Other considerations which must be weighed in borderline cases include:

1. Will the property in question be surrounded by other land where acquisition is clearly the best choice? "Islands" of land uses that are marginally compatible should not be left in the middle of an area scheduled for acquisition.

2. What will be the character of the remaining community? A single residential unit should not be left adjacent to an area that becomes predominantly industrial or commercial, after most of the residential property is acquired.

3. Are there barriers such as railroad tracks, major thorofares, or geographical features which will provide boundaries that will define the area? A small number of houses that are adjacent to a railroad track on one side and an acquisition area on another will probably eventually be converted to whatever new uses develop in the acquisition area.

4. What is the potential tax income from the property after it is redeveloped? Net cost to the government for the land acquisition should consider the tax income

> potential for the property if converted to another use. Net cost would consider the income from the resale of the acquired property, potential tax income, and adjustments for the cost to provide municipal services such as fire and police protection. The added benefits of redevelopment may compensate for a portion of the acquisition costs and make purchase of the fee simple interests cheaper than soundproofing and easements.

The results of this step will not always provide a definite answer to the problem of selecting an abatement alternative. Occasionally, the cost to purchase a property may be less than the expenses of soundproofing and other forms of compensation. It is more likely that acquisition costs will be greater than the expenses to soundproof and provide compensation. The process followed in this step still has merit, however. It provides comparative information that can be weighed against other factors in arriving at a rational selection of methods to alleviate noise impact.

Step Six: Development Controls and Regulations

Zoning, building codes, and housing codes can be an important part of a comprehensive program for managing land use around airports. These types of controls are familiar to most counties and municipalities and can generally be adapted or amended to include the provisions unique to areas of airport impact. However, although development controls are potentially effective as a means of reducing airport impact, most of the ordinances now in effect are insensitive to the problems of aircraft noise and accident potential. One of the major problems has been the lack of legislative effort to promulgate such controls. Another problem has been the lack of enforcement of controls that have been implemented.[73]

Zoning can be effective in preserving existing compatible uses, encouraging compatible uses where a dominant one has not been established, and preventing the development of incompatible uses. However, zoning is primarily a preventive strategy that can do little to change existing development. The most effective application of zoning regulations has been around newly-constructed or proposed airports located in rural, undeveloped areas.[74]

Building codes regulate the quality of construction that a county or municipality will permit. They provide an excellent opportunity to require special features such as noise-abatement materials and construction methods, where required. Opposition to strict building codes is generally centered around concern for the growth retardant effect of increased building costs and difficulties in enforcing the stricter standards.

Housing codes specify the standards that residential dwellings must meet in order to be considered suitable for occupancy. Features like ventilation, utility requirements, room area, and light availability are controlled by such regulations.

Zoning ordinances, building codes, and housing codes should be prepared as a coordinated series of regulatory controls. The provisions of the building and housing codes should be keyed to the terms of the zoning ordinance. Ideally, a zoning ordinance for an airport impacted area would discriminate between permitted land uses based on noise and accident exposure; building codes would require specific materials and types of construction in areas of noise impact; and housing codes would provide strict restrictions on types of housing allowed in an airport-impacted area.[75]

The preparation and implementation of effective development controls around an urban airport is particularly difficult. Such regulations are prepared and administered by independent counties and municipalities. Airports located in a highly-developed area, such as Hartsfield International, are often surrounded by several different counties and municipalities. Therefore, preparation of standardized regulations requires dealing with several different county and municipal agencies. This problem is often compounded by political differences and conflicts that exist between individual agencies.[76]

It has been proposed that the counties and municipalities affected by an airport be required to adopt specific standards for zoning, housing, and building codes. The implementation of such controls could be made a prerequisite for the individual county or city to receive technical assistance and program funds. This technique would provide a strong incentive for local municipalities to develop effective land use controls for airport-impacted areas.[77]

Redevelopment of Airport-Impacted Areas

The redevelopment of areas that are impacted by airport operations must be carefully planned and monitored. A well-prepared redevelopment plan can protect an airport and its operations and can contribute to the social and economic well-being of surrounding communities. Redevelopment represents a critical link in integrating the airport and its environs. In addition to returning land to productive use, the redevelopment plan must compliment the existing social and economic patterns in the area.

A Land Use Evaluation for Mountain View

This section presents an evaluation of the existing land uses in Mountain View. The evaluation is conducted using the first five steps of the strategy noted in the preceding section. These steps represent the bulk of the analytical work involved in analyzing land use around airports. Redevelopment of the area around Mountain View is not discussed in this section. The scope of such an analysis requires more discussion than can be presented in a brief section or sub-section of this chapter. The topic of redevelopment is discussed at length in the next chapter of the thesis.

The study of Mountain View is a generalized analysis that is based on many different assumptions. These assumptions are noted as they apply to the overall study and to each step of the analysis. Since the study is based upon general types of data, the results are not to be interpreted as being recommended policies or guidelines for a particular situation. Many important factors whose research is beyond the scope of this thesis must be considered in developing a program for Mountain View or for any other area. The objective of this study is to illustrate a procedural format and to show the directions that future studies of this type may take.

General Assumptions

The types of land use that are discussed in the following studies will be limited to residential, commercial, industrial, and semi-public uses. Public uses are addressed only where the existing activities are clearly out of line with the safety hazard or noise-impact levels. It is assumed that uses such as fire stations, police stations, and other municipal buildings will remain in their present locations. Institutional facilities such as schools will be removed from accident impact and high-noise areas.

The study is restricted to the City Limits of Mountain View. Adjacent land uses and activities are considered only briefly. This assumption is made in order to be able to transfer some of the data for Mountain View that was presented in earlier chapters of the thesis.

As mentioned in the introduction to this chapter, this analysis does not consider the possible reduction of noise impact that may be possible as a result of improved aircraft technology and revised operational procedures.

The references to land uses are based on a windshield survey of the Mountain View area conducted by the author in July, 1977. Land uses were evaluated based upon visual analysis of the existing structures and a study of the Clayton County tax rolls.

The various criteria used in the analysis are brought directly from the previous discussions in the thesis. Standards and guidelines are not adapted to the specific situation in Mountain View, except where absolutely required for clarity in the presentation.

Cost data that are brought forward from previous sections are converted in 1977 dollars. This is done to keep the relative values of different costs approximately equal. Even with this consideration, the cost data presented in the following analysis are not necessarily accurate for Mountain View.

Step One: Evaluation of Land Uses in the Accident-Potential Zone

The accident-potential zones affecting Mountain View and the land uses within the zones are illustrated by Figure 6.1. In evaluating this situation, the following assumptions are established.

1. The accident-potential zones illustrated in Figure 6.1 measure 2,500 feet by 5,000 feet, which is slightly wider than the dimensions mentioned in Chapter Four. These dimensions were specified in the criteria used for funding land acquisitions under the ADAP program. The justification for the land acquired under the program was that the land be necessary for airport safety. Also, the 2,500-

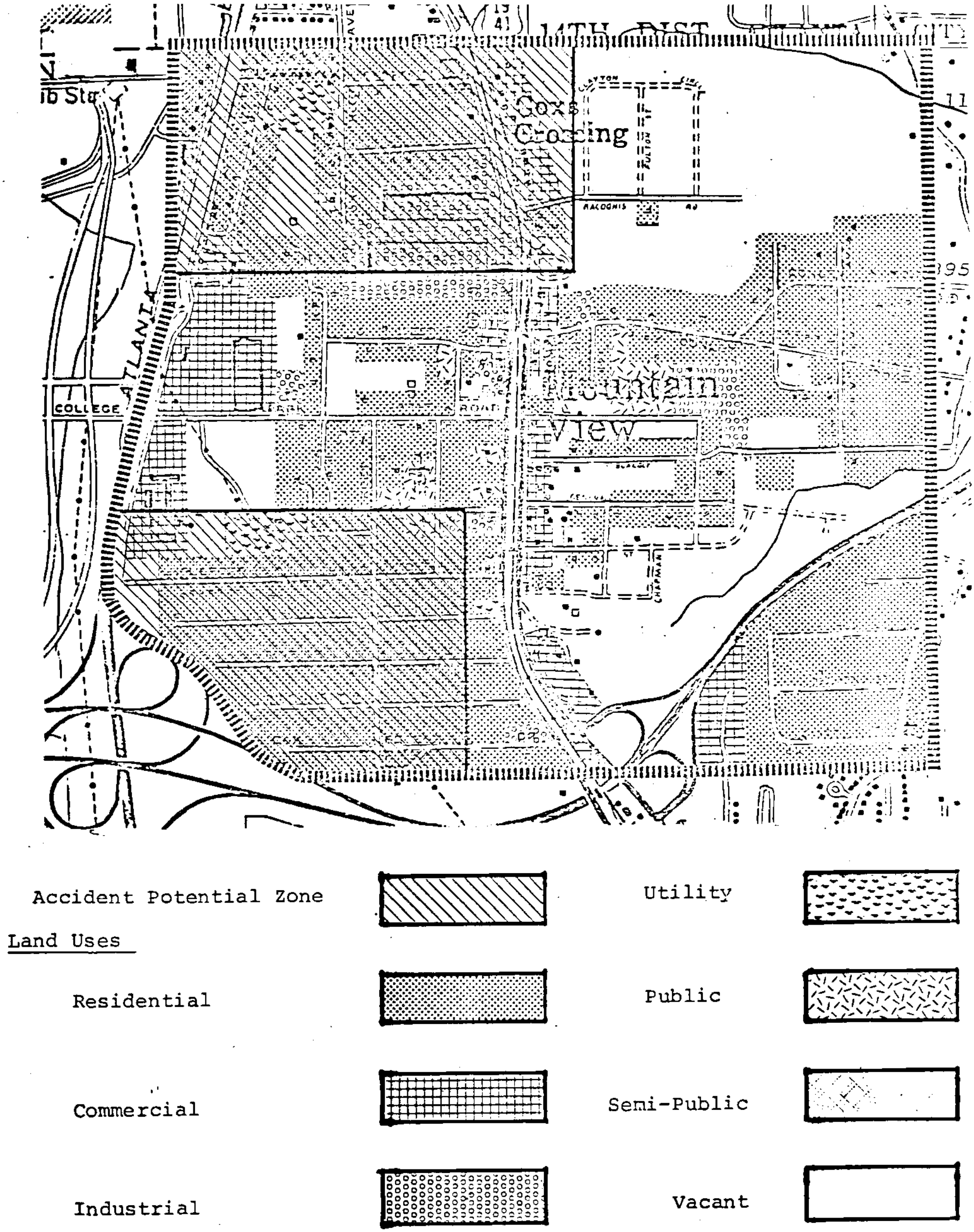


Figure 6.1. Land Use in Accident-Potential Zones in Mountain View

foot dimension includes the area of potential aircraft impact, as well as a margin of safety to account for the scattering of wreckage from a potential accident.

2. The residential areas have a population density of about four persons per acre, as determined from the population statistics in Chapter Three, Table 3.1

3. The recommended density for the accident-potential zones is .5 persons per acre, as determined in Chapter Four. This assumes a "worst case" situation, involving the crash of a Boeing 747.

4. The industrial activities in the accident-potential zone are low-density operations, such as warehousing. It is further assumed that the employee density and working hours for the industries results in an average density less than or equal to the .5 persons per acre noted above.

5. Existing commercial areas,except the motels, are small activities with low patronage and employee densities. It is further assumed that there are no high-density commercial uses in the area such as office buildings or theaters.

6. Two motels are located on the border of the accident-potential zones. Several alternatives may be taken for these developments. One would be to require the motels to relocate out of the accident-potential area. Another alternative would be to restrict the occupancy levels to conform to average annual density requirements. Expansion of the motels could be restricted to avoid worsening the situation, as a final alternative.

For the purposes of this study, the following assumptions are made on the disposition of each of the preceding cases:

1. Existing residential development in the accident-potential zone is incompatible with the crash hazard. The houses should be purchased and the families relocated. The school should also be closed.

2. Existing commercial and industrial areas will be allowed to remain, including the motels.

Step Two: Analysis of Areas Exposed to Extreme Noise Levels

This step identifies areas that are exposed to excessive noise levels and determines which noise levels cannot be effectively soundproofed. The assumptions considered in the following analysis are:

1. The noise level contours developed by Region IV office of EPA and discussed in Chapter Two are used for the analysis.

2. Soundproofing technology is available that will provide total attenuation for a structure of at least 35 dB.

3. The standard that is set for interior noise levels for residential areas is 45 L_{dn}, as established by the EPA criteria.

4. The HUD criteria for evaluating land use compatibility is used for residential areas (maximum permissible level 75 L_{dn}), commercial or industrial areas (maximum permissible level 85 L_{dn}), and transient lodging (maximum permissible level, 85 L_{dn}).

5. The maximum noise level that can be effectively soundproofed for residential uses is 80 L_{dn}. This assumes that soundproofing techniques are available as described above and that the maximum permitted interior noise level for interior residential spaces is 45 L_{dn}.

Figure 6.2 illustrates the approximate locations of the 75, 80, and 85 L_{dn} noise contours in Mountain View. All but a small part of the town is within the 75 L_{dn} contour. Therefore, based upon the HUD criteria, the majority of the City of Mountain View is in an area where residential development is considered "clearly unacceptable". Most of the area within the city is acceptable for commercial and industrial development, based upon a maximum limit of 85 L_{dn} as specified by the HUD

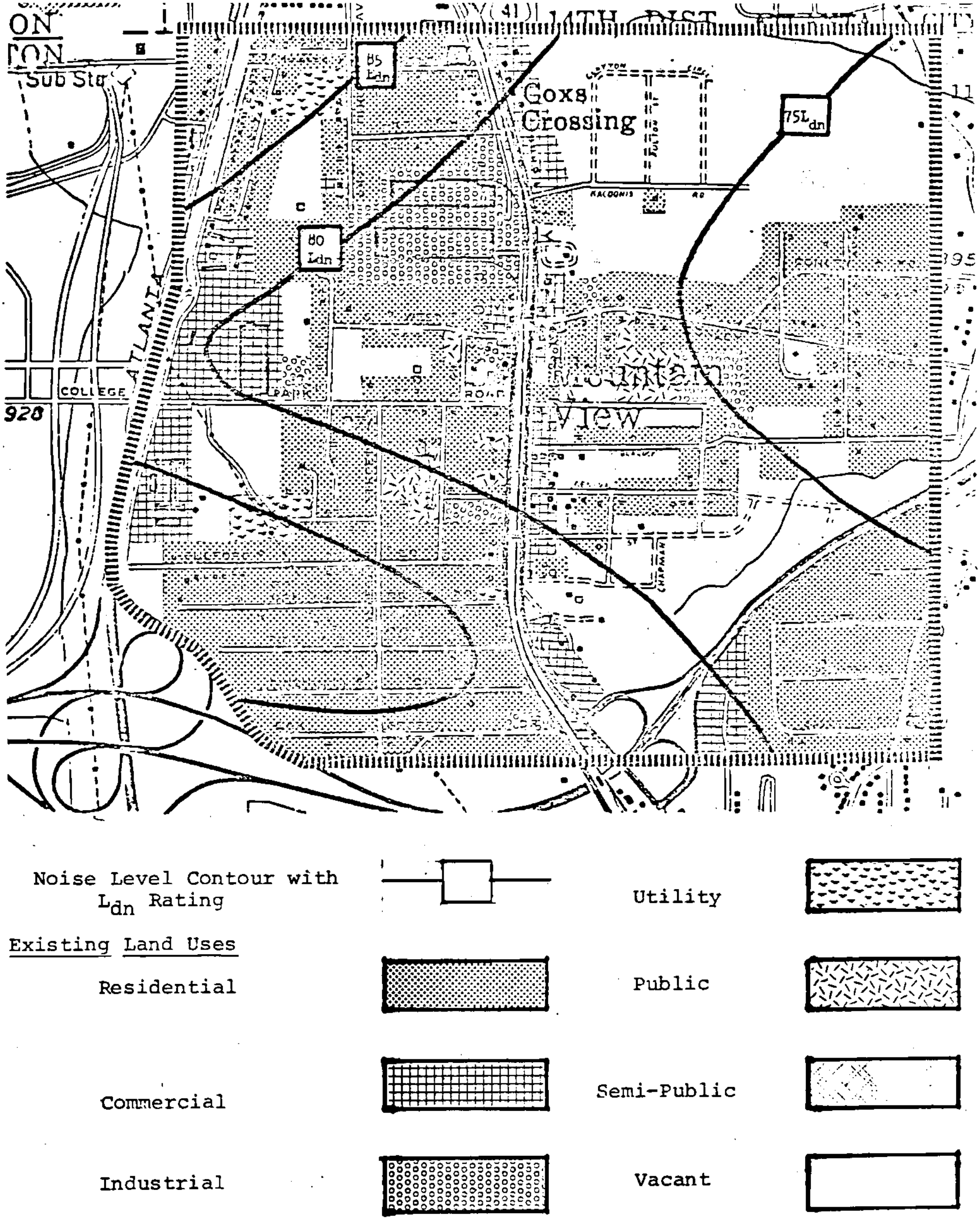


Figure 6.2. Noise Zones Impacting Mountain View

criteria. The exceptions are in two areas, one in the northwest corner of the city and the other in the southwest sector of town.

Step Three: Identification of Soundproofing Requirements

Four hypothetical residential units are used to illustrate the process of estimating soundproofing costs. The location of the units and appropriate information such as exterior noise level and type of construction, are illustrated on Table 6.1. Although all of the information shown is hypothetical, it is representative of the different locations noted in Mountain View. Other assumptions used in developing the soundproofing costs are:

1. Soundproofing would be provided for all residences in Mountain View. Present federal funding guidelines allow the preparation of projects to provide noise-abatement improvements in areas exposed to noise levels of 65 L_{dn} and greater.

2. The maximum noise levels for land uses such as commercial and industrial activities would be dependent upon varying circumstances. For this study only the specific needs for residential soundproofing are discussed.

3. All of the housing units are of light frame construction and existing climatic conditions require the use of air conditioning to provide ventilation when windows are closed. The existing structures are assumed to be in sound condition and capable of providing at least 15 dB noise attenuation in their original condition.

4. The estimates developed by the Bolt, Beranek, and Newman study, as illustrated in Figure 5,4, are used to prepare cost estimates for the various levels of soundproofing required.

Table 6.1. Costs for Soundproofing Residential Units in Mountain View

Calculation of Soundproofing Costs	Housing Unit Number[1]			
	One	Two	Three	Four
Exterior Noise Level (L_{dn})	80	75	80	70
Noise reduction required to achieve interior noise level of 45 L_{dn} (in dB)	35	30	35	25
Less noise attenuation of original structure (dB)	-15	-15	-15	-15
Required soundproofing improvement (dB)	20	15	20	10
Costs for Soundproofing [2]Structural Improvements	$8,865	$4,725	$8,865	$1,615
Airconditioning and Ventilation	1,200	1,200	1,200	1,200
Total Soundproofing Costs	$10,065	$5,925	$10,065	$2,815

[1]Locations: Unit Number One: West of Highway 41, between S. West Street and College Park Road

Unit Number Two: East of Highway 41, North of Blalock, and South of Kakoonis

Unit Number Three: East of Highway 41, South of Blalock and North of Evans

Unit Number Four: Conley Circle, near Ballard Road

[2]Type of construction for all units assumed to be light frame, with exterior walls of wood, metal, or asbestos shingle

5. Maximum permitted interior noise level is 45 L_{dn}, as established by the EPA criteria.

The results of this analysis are illustrated in Table 6.1. These results will be used in a subsequent analysis in Step Five to determine which areas should receive soundproofing.

Step Four: Assessment of Costs for Compensation

As previously noted, the use of compensation is proposed only for reduced utility of exterior spaces due to noise. Therefore, for this analysis, hypothetical costs for noise easements are calculated. Easements are calculated for the same four housing units noted in Table 6.1. The following assumptions are made in conducting this analysis:

1. The reduction of residential property values is used as the basis for estimating the costs of noise easements. This procedure assumes that the reduced utility of outside space will be reflected in the market price for a house situated in a noise-impacted area.

2. Property values are estimated to be depressed by .5 per cent for each unit of L_{dn}, noise exposure in excess of 55 L_{dn}. This figure was noted in a study of the effects of noise on property values in the Washington, D. C. area, as described in Chapter Five.

The results of this analysis are shown in Table 6.2. These results will be used in a comparison in the following step to determine where compensation may be an appropriate alternative for Mountain View property. The estimate for easement costs are a function of both housing value and noise exposure.

Table 6.2. Costs for Noise Easements for Residential Units in Mountain View

Calculation of Easement Costs	Housing Unit Number[1]			
	One	Two	Three	Four
Exterior Noise Level (L_{dn})	80	75	80	70
Percentage Reduction in Property Value due to Noise:				
# Units over 55 L_{dn}	25	20	25	15
-.5% per unit over 55 L_{dn}	x .5	x .5	x .5	x .5
Percentage Reduction of Property Value due to Noise	12.5%	10%	12.5%	7.5%
Cost of Noise Easement:				
Property Value	$19,415	$24,742	$24,742	$28,178
x percentage reduction of Property Value due to Noise	x 12.5%	x 10%	x 12.5%	x 7.5%
Reduction in Property Value due to Noise	$2,425	$2,475	$3,090	$2,115

[1]See Table 6.1 for Housing Unit Locations

Step Five: Comparison of Acquisition Costs vs. Costs for Soundproofing and Compensation

Table 6.3 illustrates a comparison of market values against costs for soundproofing and compensation of market values against costs for soundproofing and compensation for the four hypothetical housing units. Costs for soundproofing and easements come from Tables 6.1 and 6.2, respectively.

The following assumptions are made in analyzing the comparisons shown in Table 6.3:

1. All residential property west of Highway 41 would be acquired fee simple. The cost of soundproofing and noise easements are assumed to be excessive when compared to the cost for direct acquisition. Furthermore, the acquisition of residences in the safety zone will leave small pockets of residential areas. These areas would be further isolated by the railroad tracks and Highway 41 which divides the city.

2. Commercial and industrial uses would be allowed to remain at their present locations. It is assumed that any costs for soundproofing or noise easements would be substantially less than the purchase price of developed commercial or industrial property. Also, existing commercial and industrial land uses will probably be compatible with any redevelopment that occurs in the impact area.

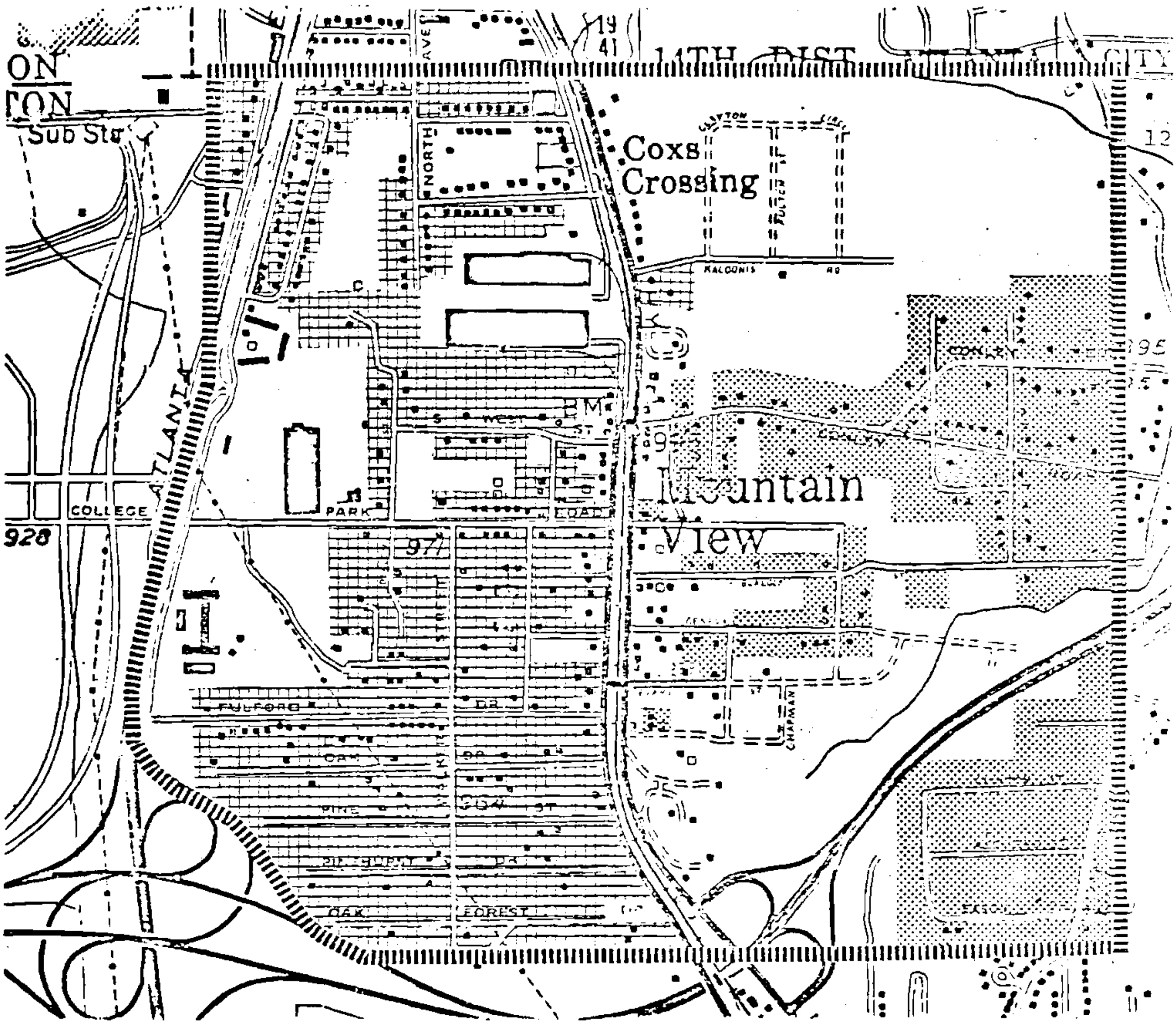
3. Most of the residential areas located east of Highway 41 would be allowed to remain. Individual structures would be soundproofed and easements purchased to compensate for exterior noise impact. The area east of Highway 41 is predominantly residential in character and most of the communities are stable and well-established.

This step completes the analysis of areas recommended for acquisition, soundproofing, and easements. Figure 6.3 illustrates the areas of Mountain View recommended for each alternative. The figure represents the net result of steps one

Table 6.3. Comparison of Market Values with Costs for Soundproofing and Easements

Comparison of Costs	Housing Unit Number[1]			
	One	Two	Three	Four
Estimated Property Value	$19,415	$24,742	$24,742	$28,178
Cost of Soundproofing and Easements				
Soundproofing Costs	$10,065	$5,926	$10,065	$2,815
Easement Costs	2,425	2,475	3,090	2,115
Total	$12,490	$8,400	$13,155	$4,930
Percentage of Soundproofing and easements of Market Value	64%	34%	53%	17%

[1]See Table 6.1 for Housing Unit Locations



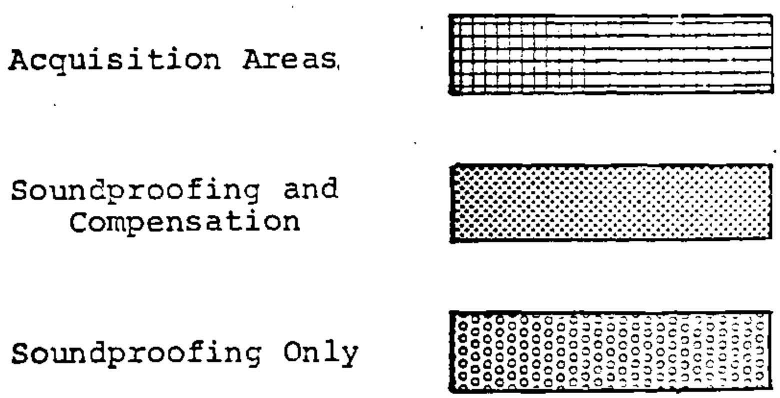


Figure 6.3. Areas of Mountain View Recommended for Acquisition, Soundproofing, or Compensation

through five. Areas recommended for acquisition include property in crash hazard zones and land where purchase of fee simple interest is economically more desirable. Soundproofing and easement requirements are also illustrated.

Conclusions of the Land Use Analysis for Mountain View

The extent of the problems of airport impact on the City of Mountain View became evident upon completions of Step Two of the analysis. At that point the accident-potential zones and the high-noise impact areas had been identified. In addition, instances where technological improvements such as soundproofing may help conserve noise-impacted areas were defined.

For the Mountain View analysis it was determined that the entire city, or all area within the 75 L_{dn} noise zone, is heavily impacted by noise, based upon the current HUD criteria for land use compatibility. The area where improvements such as soundproofing may be feasible was determined to be outside of the 80 L_{dn} noise contour, based upon EPA criteria for interior noise levels and present soundproofing capabilities. Therefore, the area between the 75 and 80 L_{dn} noise contour requires further in-depth study regarding selection of recommended alternatives.

The potential magnitude of the airport-impact problem requires that some alternatives be considered besides buying property and relocating families. As noted earlier, the project to relocate 440 families from Mountain View will cost in excess of 16 million dollars. At that rate the cost to relocate all 740 families from Mountain View would cost almost 27 million dollars. Extension of these costs for the entire area impacted by Hartsfield International Airport results in a total in excess of 850 million dollars.

The alternatives described by the preceding analysis gives a general indication of the approximate costs for the different techniques that were illustrated. Table 6.4 presents a summary of the total costs described in the analysis of Mountain View. The table also illustrates the estimated costs for acquisition of all residences in the impacted area and the relocation of the families. Costs for easements and soundproofing were developed by applying the estimates calculated in Table 6.3 to the total housing units in the representative area. Costs for acquisition and relocation are based upon the current project costs for the relocation program now underway in Mountain View.

The estimates noted in Table 6.4 must be compared cautiously, as they represent reasonably accurate costs (the relocation expenses for Mountain View), and fairly general costs (costs for soundproofing and easements). However, the relative difference between the two alternatives is considerable. Total acquisition is estimated to cost in excess of 27 million dollars, as compared to less than 19.2 million

Table 6.4. Comparison of Alternative Programs for Mountain View

Cost Item	Acquisition of all residential structures in the noise-impacted area and relocation of all residents	Combination of acquisition and relocation, soundproofing, and compensation
Cost for acquisition and relocation	$27,000,000[2]	$16,000,000[1]
Costs for soundproofing and noise easements	-	3,150,000[3]
Total Program Costs	$27,000,000	$19,150,000

[1]Program cost estimate to relocate 440 families from western side of Mountain View

[2]Costs to relocate 740 families @ $36,400 per family, based on program cost estimate for current relocation program

[3]Based on the costs to provide soundproofing for:

177 units @	$13,155 per unit	(Unit No. 3)	=	$2,328,435
61 units @	$8,400 per unit	(Unit No. 2)	=	512,400
62 units @	$4,930 per unit	(Unit No. 4)	=	305,660
		Total	=	$3,146,495

Costs estimates for soundproofing and easements for Units 2, 3, and 4 are illustrated on Table 6.3 Distribution of 177 units to No. 3; 61 units to No. 2; and 62 Units to No. 4; is based upon estimated allocation of units shown on Table 3.1 in Chapter Three.

dollars for the use of soundproofing and compensation in some areas. Furthermore, it is likely that the costs for acquisition and relocation of all impacted areas will be somewhat greater. That estimate is based on the figures for the relocation project underway in western Mountain View, while housing values are about 15 per cent higher in the eastern part of the city (see Table 3.1). This increase would result in an even larger margin between the estimates for the two alternatives.

CHAPTER SEVEN

LAND DEVELOPMENT IN THE AIRPORT ENVIRONS

This chapter describes the process of planning for the development and use of land in the airport environs. Planning for land development represents the final step in the preparation of the land use element of an airport environs program. The objective of this phase is to develop a land use plan that is compatible with the airport environment, provides a productive use of the land, and is integrated into the social and economic patterns of the community.

The first section describes the planning considerations that should be addressed in preparing a development plan for land around airports. The next section discusses the suitability of various land use forms within the airport environment. In the third section, discussion includes subterranean development and its application to the land on and around airports. The final section describes a recommended land use plan for the redevelopment of Mountain View, Georgia.

Planning Considerations in the Airport Environment

Planning around airports is limited by considerations such as geography, transportation access, economic and social needs of the community, and availability of utilities. However, airport environs are also subjected to unique restrictions such as noise, aircraft accident potential, and airspace controls. Each of these are discussed, briefly, below.

Noise in the Airport Environment

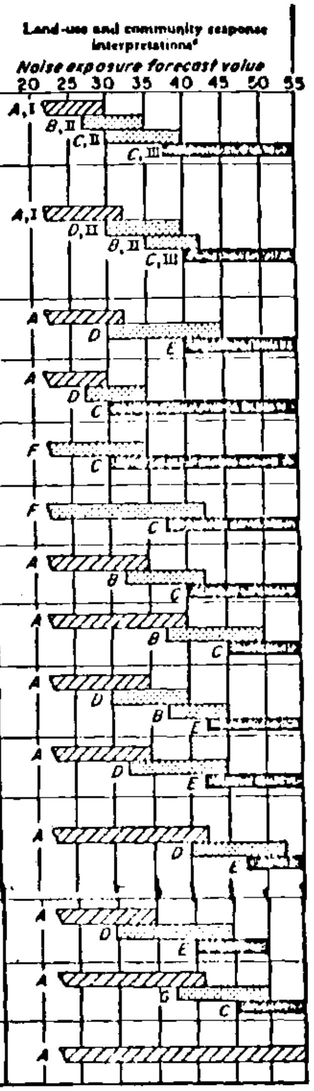
The impact of airport noise has been discussed at length in earlier portions of this report. As described in Chapter Four, the present HUD criteria allow considerable flexibility in developing compatibility standards for a specific area. The HUD standards can be adjusted for differences in receiver sensitivity and other variable factors. The EPA guidelines, on the other hand, propose extremely low "target" noise levels that cannot presently be applied as practical standards.

Figure 7.1 illustrates the criteria to be used in the analyses in this chapter. These are based upon the HUD guidelines discussed earlier, but are stricter for the recommended levels for land uses such as residential, schools, and hospitals. The guidelines in Figure 7.1 also include detailed recommendations for permitting new construction in the different noise zones.

Aircraft Accident Potential

The risk associated with a potential aircraft accident was previously described in Chapter Four. That analysis showed that it is possible to determine a maximum population density that should be maintained in an accident potential area, in order to reduce the odds of someone on the ground being killed by a plane crash. For the analyses prepared in this chapter, an average annual density of .6 persons per acre is recommended

Land-use category	SLUCM code[a]	Noise sensitivity code[b]
Residential—single and two family homes, mobile homes	11x[d], 14	1
Residential—Multiple family apartments, dormitories, group quarters, orphanages, retirement homes, etc.	11x, 12, 13, 19	2
Transient lodging—hotels, motels	15	3
School classrooms, libraries, churches, hospitals, nursing homes, etc.	68, 651	1
Auditoriums, concert halls, outdoor amphitheaters, music shells	721	1
Sports arenas, out-of-door spectator sports	722	3
Playgrounds, neighborhood parks	761x	3
Golf courses, riding stables, water-based recreational areas, cemeteries	741x, 743, 744, 624	4
Office buildings, personal, business and professional services	61, 62, 65[e], 69, 63	3
Commercial—retail, movie theaters, restaurants	53, 54, 56, 57, 59	3
Commercial-wholesale & some retail, industrial/ manufacturing, transportation, communications & utilities	51, 52, 64 2xx[f], 3xx 4xx	5
Manufacturing—noise sensitive communications—noise sensitive	35[g], 47[g]	3
Livestock farming, animal breeding	815-817	4
Agriculture (except livestock farming) mining, fishing	81 NEC[h] 82, 83, 84, 85, 91, 93	5



[a] Standard land use coding manual.
[b] Relative ranking of land uses with respect to noise sensitivity. See text for approximate relationships to NEF values.
[c] Interpretations are listed in Table A-2.
[d] "x" Represents a SLUCM category broader or narrower than, but generally inclusive of, the category described.
[e] Excluding hospitals.
[f] "xx" some exceptions may occur for particular or specialized noise-sensitive activities.
[g] Dependent upon specific task requirements.
[h] Not elsewhere classified.

General land-use recommendations*

A. Satisfactory, with no special noise insulation requirements for new construction.
B. New construction or development should generally be avoided except as possible infill of already developed areas. In such cases, a detailed analysis of noise reduction requirements should be made, and needed noise insulation features should be included in the building design.
C. New construction or development should not be undertaken.
D. New construction or development should not be undertaken unless a detailed analysis of noise reduction requirements is made and needed noise insulation features included in the design.
E. New construction or development should not be undertaken unless directly related to airport-related activities or services. Conventional construction will generally be inadequate and special noise insulation features must be included. A detailed analysis of noise reduction requirements should be made and needed noise insulation features included in the construction or development.
F. A detailed analysis of the noise environment, considering noise from *all* urban and transportation sources should be made and needed noise insulation features and/or special requirements for the sound reinforcement systems should be included in the basic design.
G. New development should generally be avoided except as possible expansion of already developed areas.

Community response predictions†

I. Some noise complaints may occur, and noise may, occasionally, interfere with some activities.
II. In developed areas, individuals may complain, perhaps vigorously, and group action is possible.
III. In developed areas, repeated vigorous complaints and concerted group action might be expected.

* Land use recommendations are based upon experience and judgmental factors without regard to specific variations in construction (such as air conditioning and building insulation) or in other physical conditions (such as the terrain and the atmosphere). These features and others involving social, economic, and political conditions must be considered in recommending individual use and density construction combinations in specific locations.

† Community response predictions are generalizations based upon experience resulting from the evolutionary development of various national and international noise exposure units, in particular, the composite noise rating (CNR). For specific locations, considerations must also be given to the background noise levels and the social, economic, and political conditions that exist.

Noise sensitivity code	Approximate noise exposure forecast value where new construction or development is not desirable
1	30
2	35
3	40
4	45
5	50-55

Figure 7.1. Recommended Land Use Guidelines for Noise-Impacted Areas

Source: Horonjeff: Planning and Design of Airports for the accident-potential area. This density assumes that the "average" crash would involve an aircraft weighing about 550,000 pounds.

The discussion of accident potential in Chapter Four also established the area in which an aircraft accident is most likely to occur. Typically, a safety zone measuring about 5,000 feet long by 1,500 feet wide should be maintained off the end of a runway. For the purpose of the discussions in this chapter, the 5,000-foot by 2,500-foot area described in Chapter VI is acceptable.

Airspace Restrictions

The number and size of runways at an airport are related to demand for aviation services and the types of aircraft that will use the facility. Once demand and aircraft type are determined, rigid limits are placed on the land use and air space immediately surrounding the runways. "Imaginary Surfaces" establish the air space that must be kept free from any type of development or obstruction.[78] A set of typical imaginary surfaces are illustrated by Figure 7.2.

Building heights near an airport must consider the imaginary surfaces imposed by the runway system. Generally, height is regulated by methods such as zoning ordinances or by easements to purchase the required airspace from the land owners. Permitted heights will vary, depending upon distance from the runway and the type of runway.

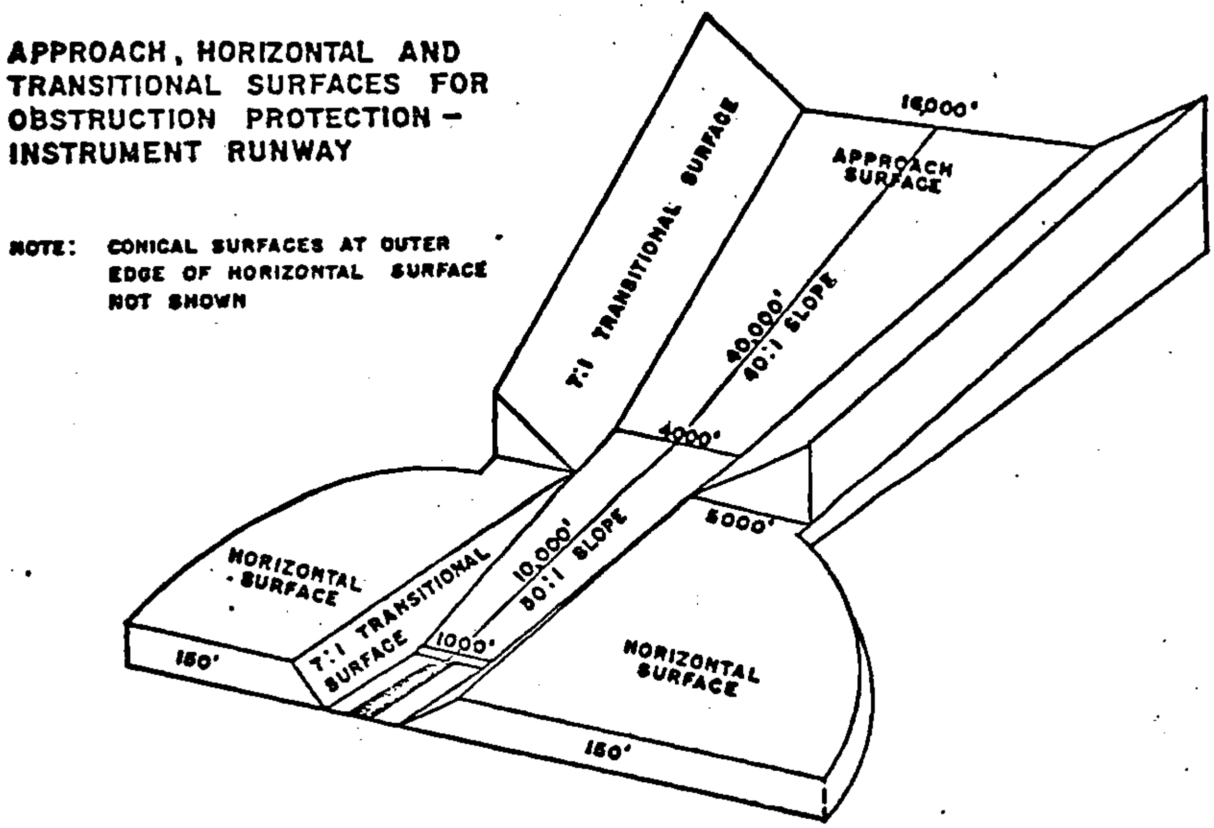


Figure 7.2. Typical Imaginary Surfaces for a Civil Aviation Runway

Fource: International City Managers Ass'n, Principles and Practices of Urban Planning

Land Development in the Airport Environs

Various forms of land use are affected differently by the environmental restraints encountered near an airport. The importance of noise and accident potential will vary between residential, commercial, and industrial types of development. An analysis of the significance of noise and accident potential on these major forms of development is described below.

Residential Development

Airport impact on residential areas is a topic of considerable controversy. Housing areas and neighborhood communities are extremely sensitive to aircraft noise. The potential risk of an airplane accident in a residential community has become a sensitive issue around many airports.

The criteria illustrated in Figure 7.1 describe the recommended noise levels for single-family and multi-family development. Although single-family uses can be located in areas of noise exposure up to 65 L_{dn}, new construction generally should not be considered where this level is exceeded. Exceptions may be allowed in areas of noise exposure up to 70 L_{dn}, if adequate noise insulation is provided. The recommended levels for multi-family development are slightly higher. Development of new multi-family housing may be permitted in areas exposed to noise levels up to a maximum of 75 L_{dn} if noise insulation features are included in the construction.[79]

Accident potential is important in evaluating residential development. Generally, severe noise levels will extend beyond the limits of the accident-potential zone and residential construction will be discouraged on the basis of noise impact. However, as aircraft become quieter and operational techniques are adjusted to reduce noise impact, the noise zones may be reduced. As the high noise zones are brought closer to the airport, the accident-potential zone may become more of a factor in regulating high density land uses such as single and multi-family residential.

As a general rule, residential development of any form should be prohibited within the accident-potential zone. Where some degree of residential development is unavoidable, the principles noted in Chapter Four, regarding maximum acceptable density of population, should be followed. Population densities in accident-potential zones should be kept as low as possible.

From a purely objective point of view, the airport environs outside of the accident-potential zones could provide a desirable residential location if the noise problem could be fully corrected. Residential developments near an airport would benefit from the easy access to highways and major thoroughfares and would be convenient to a major employment center. These benefits would be of particular value to low-cost housing developments, where convenience to transportation, work, schools, and shopping are more important than a prestigious location.[80] Residential development that is convenient to an airport, but removed a sufficient distance from it to be protected from the noise problem, could enjoy distinct locational advantages.

Commercial Development

Commercial forms of development may be used to maximize the use of property in the airport environs. For this analysis, development considerations for office parks and shopping centers are discussed. Airport impact on these two forms of development is described through discussions on locational criteria, noise sensitivity, and suitability in accident-potential areas.

Office Parks. Office parks are developed in a variety of forms and may range in size from 20 to 200 acres. The primary objective in planning an office park is to create and maintain an atmosphere of quality appearance and superior working conditions. Some of the points that must be considered in evaluating a location for an office park are:[81]

1. Access to Transportation. The most appropriate locations are those on major traffic arteries, particularly interstate highways that serve a metropolitan center.

2. Proximity to Residential Areas. Prestige is an important feature of an office park and the quality of surrounding residential areas largely determines the status of an office park. Time-to-work for employees is also a factor that encourages office park locations to be convenient to residential areas.

3. Availability of Supporting Services and Activities. Needs such as restaurants, shopping, and banking facilities must be met for park employees. These are often met by developing office parks adjacent to regional shopping and commercial centers.

4. Availability of Land. Control of land around an office park is important if a developer intends to prevent unwanted forms of development from destroying the appeal of the area.

The criteria listed in Figure 7.1 indicate that office buildings are appropriate in areas with noise levels up to 75 and 80 L_{dn}. In areas of highest noise, construction methods must provide adequate soundproofing. Also, in evaluating noise, the outdoor noise levels must be considered. Most successful office parks are designed to allow the use of the exterior spaces by employees for lunch, recreation, and relaxation.

Office parks are generally not appropriate in accident-potential zones. Most office parks will attract over 200 employees per acre. As noted in the previous section, the maximum recommended population density in the accident-potential zones is generally less than one person per acre. This density considers the period of time that an area is actually occupied. In other words, two employees per acre during a 40-hour work week would give an average density of about .5 persons per acre, when averaged over an entire 168-hour week (seven 24-hour days).

Convenient access to local commercial airports is important, particularly for offices with a large percentage of executives and salesmen who use air travel extensively. Generally, however, a location that is within a ten to fifteen-minute drive from an airport is more desirable than one which is immediately adjacent to it. The noise, congestion, and general disruption around airports may detract from the environmental quality that is important to successful office parks.[82]

Shopping Centers. Shopping centers are planned groups of commercial establishments that serve neighborhood, community, or regional markets. Shopping centers range in size from less than ten to over a hundred acres. Some of the locational characteristics to consider in evaluating a site for a shopping center are:

1. Convenience to Trade Area. Success of a shopping center depends upon the availability of a sound market area. Related to this requirement is the ability of the center to protect itself from competition which may intercept its market.

2. Access to Transportation. The shopping center site must be easily accessible from all points of the market area. At the same time, traffic generated by the center should not travel through established residential areas.

Retail commercial development is suitable in areas with noise levels up to 70 L_{dn}, according to the criteria in Figure 7.1. Exterior noise levels up to 80 L_{dn} are acceptable, provided that special soundproofing features are incorporated into the construction. One form of commercial development which may adapt well to noise-impacted areas in the enclosed shopping mall. Enclosed malls are often used for large shopping centers and provide a totally controlled environment within the center. This type of design lends itself easily to effective soundproofing techniques that would be needed to overcome the excessive noise levels around airports.

Accident-potential zones are unacceptable locations for shopping centers. As with office parks, large numbers of people occupy a shopping mall and the average population densities in such an area would be prohibitive.

The suitability of a shopping center around an airport will depend primarily upon the availability of a market. Although an airport would probably generate considerable business from passengers and employees, the local area market would still be important. If an area market is lacking, it is doubtful if the airport alone would support a major shopping center.[83]

Industrial Development

Industrial development offers the greatest potential for the productive use of land in the airport environs. Industrial activities are generally compatible of the noise levels around airports and provide a contribution to an area's economic base. Several of the basic factors to be considered in evaluating industrial development are described briefly below, followed by a discussion on the application of the industrial park concept to the airport environment.

General Site Considerations. Location is the most important factor in evaluating potential for industrial development. Some of the primary considerations in evaluating a location include:[84]

1. Access to Transportation. Convenient access to main highways and thoroughfares is of primary importance to an industrial site. Perimeter routes and

beltways are considered as choice locations. Rail access is also important and adds a great degree of flexibility to an industrial site. The best sites are those with at least 1,000 feet between the major highway and the nearest rail line. Access to airports is becoming more important as the air freight industry continues to grow. Waterways provide another dimension in transportation, where it is available.

2. Availability of Utilities. The availability of gas and electric power is a vital consideration. However, the controlling element is water supply. The availability of a public water supply will usually determine the location of an industrial area and the types of activities that can be conducted in it.

3. Topographic and Subsurface Characteristics. Topography is an important, but not controlling element in industrial development. Tracts suitable for growth by virtue of their location can generally be adapted to irregular topography.

4. Surrounding Environment. The condition of adjacent residential, commercial, and industrial development will have a significant influence on the attraction of an industry to an area. Adverse environmental factors such as air and water pollution will also have an effect.

Based upon the noise compatibility criteria illustrated in Figure 7.2, most forms of industrial development are appropriate in areas with noise levels up to 77 L_{dn}. Industrial development can be considered in areas with noise as high as 85 L_{dn}, if appropriate soundproofing measures are included. An exception to these limits is noise-sensitive industry, such as electronics and communications manufacturing, which should be exposed to noise levels no greater than 80 L_{dn}.

Employee density on industrial sites varies significantly between different types of operations. Therefore, compatibility with the risks of a location in an accident-potential zone will depend upon the type of industry being considered. Heavily automated industries may have fewer than five employees per acre, light service industries will generally have between 5 to 20 employees per acre, and machinery plants may have up to 100 employees per acre.[85]

Proximity to an airport has become an important factor for many industries. Airport locations have a significant attraction to industries with:

1. Widely-dispersed locations for production plants, warehouses, research facilities, and regional offices;
2. Divisions that custom-build special equipment, supply special parts, provide maintenance services, or provide engineers for clients with dispersed locations;
3. Warehouse and distribution centers for parts and perishable goods, seasonable merchandise, and high-value goods; and
4. Operations that are related to air freight.[86]

Airports can be expected to increase in importance as an influence on industrial site selection. Several developers already specify proximity to an airport as a major factor in choosing a site for new industrial development.[87]

The Industrial Park. The industrial park was originally conceived to make manufacturing areas more compatible with surrounding land uses such as residential developments. To accomplish this, the industrial park is managed by a developer, or controlled through deed restrictions to establish and preserve a quality atmosphere.

The industrial park concept has direct applicability to the airport environment. Physical design standards are maintained for street and utility systems, landscaping, lot coverage, building height, and architectural suitability. Operational standards are established for management, planning, community relations, and supervision of environmental conditions. By adhering to strict standards, an industrial park can be carefully and effectively managed to remain compatible with the airport environs.[88]

The types of industries normally found in industrial parks are generally compatible with the environmental restrictions around an airport. Manufacturing activities are the dominant use in an industrial park.[89] However, the types of manufacturing that are usually permitted do not generate smoke, dust, and other exhaust discharges that could present a hazard to aircraft. The second most common activity in an industrial park is warehousing and distribution centers, which have almost no adverse environmental effects.[90]

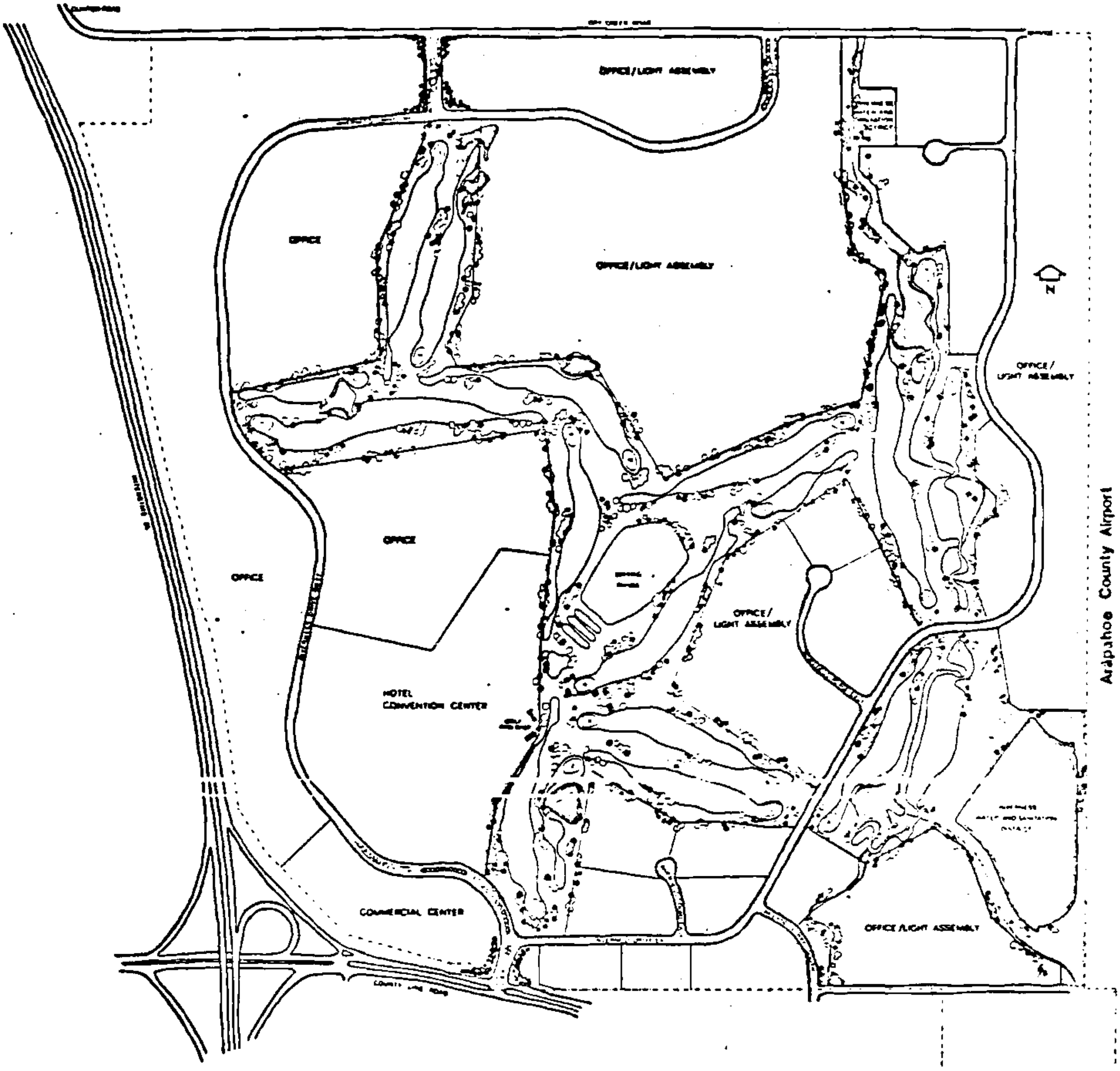
Employee densities are relatively low in industrial parks, as compared to other manufacturing districts. This is particularly important in evaluating the population density in the accident-potential zones. The average employee density for industrial parks is about 8.5 employees per site acre (area occupied by an industry, less roads and easements).[91] Approximately 65 per cent of all industrial park employers have employment densities of less than 20 workers per site acre.[92]

Industrial park developments are becoming more innovative in their planning and development concepts. Figure 7.3 illustrates one plan that incorporates a golf course into the park layout. The golf course serves a dual function as an aesthetically-pleasing recreational area and as an integral part of the site drainage plan for the park. The open space area is used to provide natural areas for surface flow of water and to minimize the amount of impervious surface in the development.[93]

Industrial parks are becoming models for integrated land use patterns. Although industry remains the basic use, other forms such as public and semi-public, recreational, and commercial and office areas are being blended into the industrial park. The Planned Unit Development (PUD) is often used to implement design and planning trends such as these.[94]

Subterranean Development: A New Concept

The concept of building below the earth's surface instead of above it offers many unique advantages. Recent construction of subterranean facilities has indicated significant conservation of energy used in heating and cooling. As land becomes more scarce, underground construction will offer another dimension to urban development. The noise insulation features of subterranean concepts, combined with the potential use in accident-hazard areas, encourages the consideration



Inverness site plan. The growing variety of land uses found within the industrial environment is indicated by Inverness, Arapahoe County, Colorado. An 18-hole golf course provides the setting for industry. A hotel-convention center and commercial center are also planned.

Figure 7.3. A Golf Course Setting for an Industrial Park

Source: Urban Land Institute, Industrial Development Handbook of an underground approach for future development around airports.

Cost and Engineering Considerations of Subterranean Construction

The costs for surface forms of construction have risen at a rate of about ten per cent per year, due to increased costs for labor, materials, and property. However, costs for underground construction methods have risen less than two per cent during the same period. From 1960 to 1970 costs for surface construction increased by over 60 per cent, while subterranean construction costs increased by about ten per cent.[95]

The two basic types of underground construction are tunnelling and underground chambers. Tunnels have been dug in the past using "drill and blast" techniques, which involve a tedious process of blasting, hauling away dirt and rock, and finishing the tunnel surface. Recently, tunnels have been dug, using a "mole", which continually carves away dirt and rock in the path of the tunnel. Underground chambers are built using the drill and blast technique, where large spaces are excavated beneath the ground surface. One concept which is being considered is the application of high-production mining and quarrying techniques to develop larger chambers in a more efficient manner. Presently, the cost to excavate large underground chambers up to 800 feet down is about seven dollars per cubic yard.[96]

Potential Applications of Underground Concepts

In the past, underground forms of development have been limited to relatively shallow excavations and construction. Subways, parking areas, and utility distribution are the most familiar forms of subterranean construction. Storage areas and military defense installations are also commonly built below, instead of on, the surface. However, beyond a few isolated examples of an underground concept for a campus library or portions of an airport terminal building, innovative uses of subterranean construction are not common.[97]

There are many possible applications of underground construction which are beginning to be seriously considered. Systems that use tunnels and underground chambers for the collection and treatment of waste water are being studied by the City of Chicago. Subterranean sites for nuclear power generating plants are a possibility and may allow the siting of such stations closer to the cities that they serve. Tunnels have long been used in transportation and may provide alternative solutions for crosstown traffic routes. Some industrial processes may actually benefit from the advantages of a subterranean site, including moderate temperatures and insulation from exterior noise and weather. Finally, the byproduct of a major excavation project--the dirt and rock removed from the site--may prove to be a valuable resource as the availability of quarries and borrow pits in urban areas decreases.[98]

Use of the Subterranean Concept in the Airport Environs

Underground construction has its greatest potential in areas where conventional forms of development are unsatisfactory. Areas of intense noise and accident potential around airports are particularly suited to the possible use of subterranean development. A new dimension in development of the airport environs is possible, if the land previously set aside for protection from aircraft noise and accidents is made available for underground use.

Although subterranean concepts offer a very real option for future development, they are not readily applicable on a large scale basis at the present time. Therefore, underground development should be considered as a future alternative for developing the airport environs. However, steps should be taken to insure that the alternative is kept open to use underground development techniques at some time in the future. Land such as accident-potential zones, which is now unsuitable for many conventional forms of development, should be placed in an interim use that is easily adapted to later development of the subterranean space. The area will then be available when construction technology and the lack of developable land make underground concepts more feasible and necessary.

A Redevelopment Plan for Mountain View

The purpose of this section is to prepare a recommended land use plan for the developable land in Mountain View after acquisition of incompatible land uses is complete. The proposed acquisition areas and land uses that should be permitted to remain are described in Chapter Six and illustrated on Figure 6.5. All criteria and guidelines used in this analysis are from previous discussions in this and other chapters.

This analysis of recommended land uses is primarily oriented to environmental restraints. Only brief attention is given to market considerations, although a complete airport environs program should include such a study. A market feasibility study to determine the land uses most appropriate to an area's economy should be conducted concurrently with the analysis described in this report.

The methodology used in preparing the land use plan involves three basic steps. First, the environmental restraints that must be considered are identified. Then, a listing of land uses that are compatible with the various constraints are identified. Finally, the various land uses are assigned to particular areas according to environmental compatibility and sound land use practice. The execution of these steps for Mountain View is illustrated below.

Identification of Environmental Constraints

Environmental factors that should be considered in preparing a land use plan for airport environs include accident potential, noise impact, and height restrictions. Each of these constraints may affect a single area, depending upon relative location to the airport.

Accident Potential and Noise Impact. Figure 7.4 illustrates both the accident-potential zones and the noise level contours discussed in previous sections of the thesis. The area designated as the accident-potential zone should be restricted from land uses and activities that generate high-population densities. An average annual density of .5 persons per acre was determined to be a maximum safe concentration of people, based upon the criteria used in evaluating crash hazard around Oakland-Alameda airport. Noise levels affect various forms of land use differently; however, the existing noise levels in Mountain View generally are not suitable for any form of single-family residential development. The criteria described in Figure 7.1 may be used to evaluate other proposed land use forms.

The impacts of accident potential and noise impact can be summarized in seven basic categories, as illustrated by Figure 7.4:

Noise Impact Only:

1. Areas exposed to noise levels of 70-75 L_{dn}
2. Areas exposed to noise levels of 75-80 L_{dn}
3. Areas exposed to noise levels of 80-85 L_{dn}
4. Areas exposed to noise levels of 85-90 L_{dn}

Accident Potential and Noise Impact:

5. Areas in the Accident Potential Zone (APZ) and exposed to noise levels of 75-80 L_{dn}
6. Areas in the APZ and exposed to noise levels of 80-85 L_{dn}

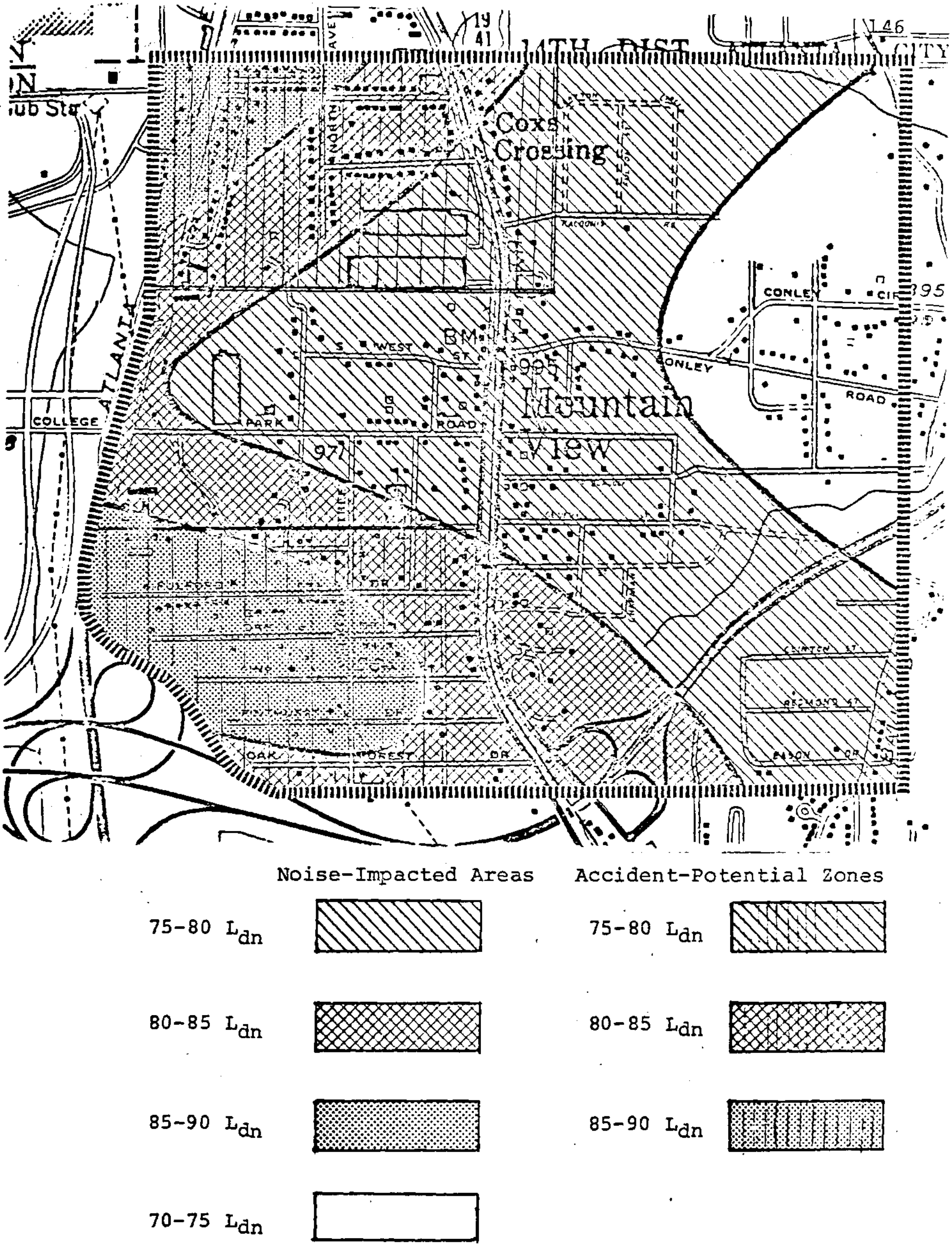


Figure 7.4. Airport Impact Zones for Mountain View

7. Areas in the APZ and exposed to noise levels of 85-90 L_{dn}

These seven categories can be used to evaluate potential forms of development in Mountain View. Individual site locations can be analyzed to determine the type and extent of the impacts affecting the area and the proposed land use compatibility evaluated accordingly.

Airspace Restrictions

The City of Mountain View is situated entirely within an area where building heights are restricted by the "Horizontal Surface". The horizontal surface is an imaginary horizontal plane that extends 10,000 feet from either side of the runway and covers a 10,000-foot radius from the ends of the runway. The horizontal surface is 150 feet above the airport elevation. The established field elevation for Hartsfield International Airport is 1,026 feet above sea level; therefore, no obstructions should extend beyond an elevation of 1,176 feet within the area covered by the horizontal surface.

Several areas in Mountain View are subject to even stricter airspace requirements at the ends of the runways. "Approach Zones" are imaginary surfaces that extend from ground level at the end of a runway and rise along the extended runway centerline at a prescribed rate of increase. Approach zones affect Mountain View approximately in the area previously described as the safety zone. Permitted elevations in these areas are restricted to anywhere between 1,076 to 1,176 feet above sea level, depending upon proximity to the runway.

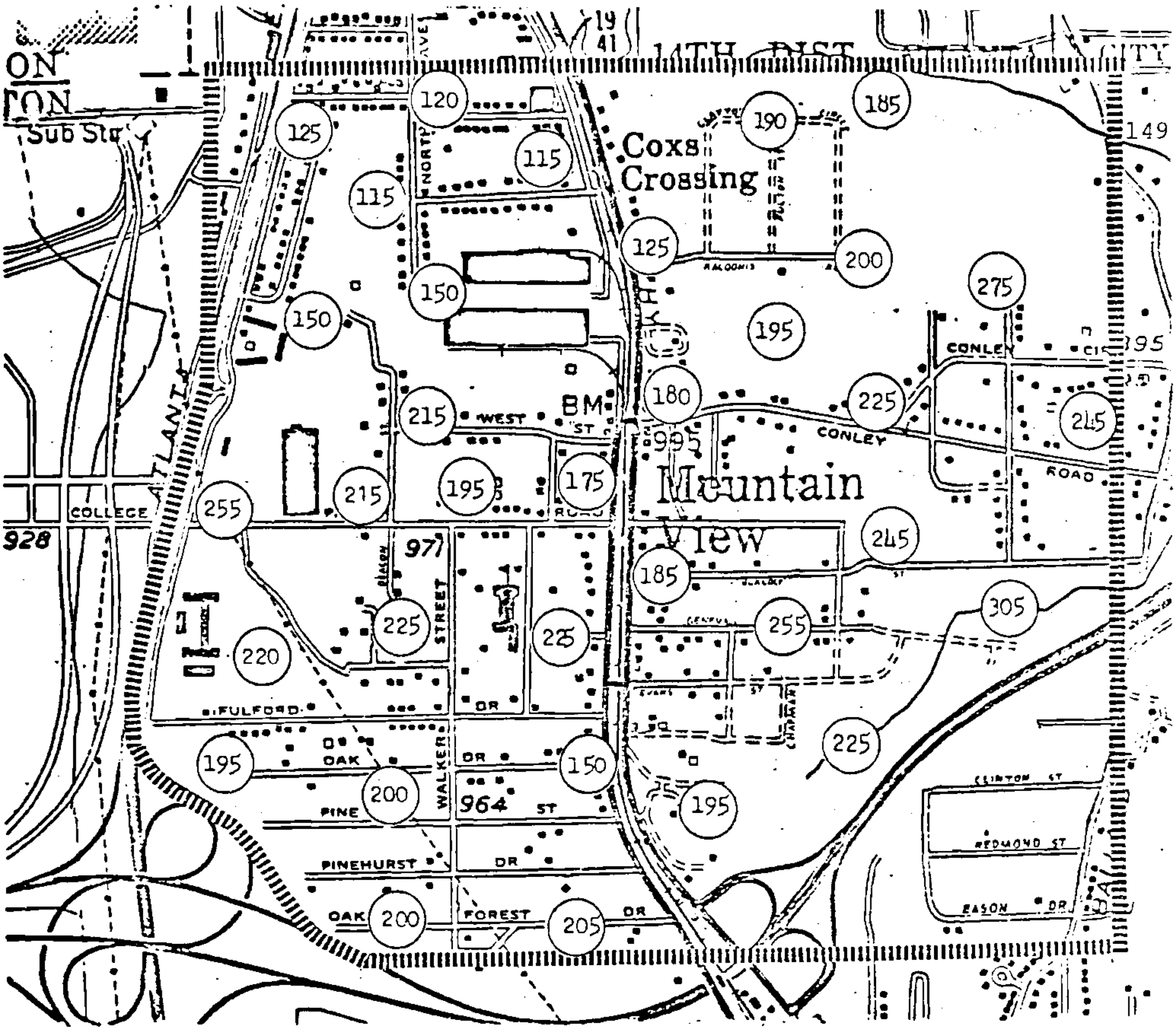
Figure 7.5 illustrates permitted building heights throughout the Mountain View area. These heights were determined by comparing ground elevation, as shown on U. S. Geological Maps,and permitted elevations allowed by the imaginary surfaces. It should be noted that these heights are approximations only and that specific cases should be evaluated using a complete field survey.

Compatible Land Uses for Future Development in Mountain View

The matrix illustrated in Table 7.1 describes the permitted land uses in each of the impact zones shown in Figure 7.4. The recommended land uses are based upon noise sensitivity and employee density as described in previous sections of the report. It should be noted that the matrix addresses only productive land uses and does not cover public, semi-public, and recreational forms. Those types of land use were not considered, as the basic intention of the study is to determine the optimum combination of productive uses for the impact area.

The Land Use Plan

A recommended land use plan for the redevelopment of Mountain View is illustrated in Figure 7.6. The patterns that are proposed are based upon the compatible uses presented in Table 7.1. The plan that is illustrated is designed to provide a combination of land uses that are well adapted to the airport



Approximate Permitted Building Height (in feet)

Figure 7.5. Permitted Building Heights in Mountain View

Table 7.1. Land Use Compatibility Matrix for Mountain View

Land Use	Impact Zone[1]						
	Noise Impact				Noise Impact and Accident Potential		
	70-75 Ldn	75-80 Ldn	80-85 Ldn	85-90 Ldn	75-80 Ldn	80-85 Ldn	85-90 Ldn
Residential							
Single-Family							
Multi-Family	x						
Transient Lodge.	x	x					
Commercial							
Office Bldgs.	x	x			x[2]		
Retail, Movies, Restaurants	x	x					
Industrial							
Warehousing	x	x	x	x	x	x	x
Distribution	x	x	x	x	x	x	x
Utilities	x	x	x	x	x	x	x
Noise Sensitive Manufacturing	x	x			x[3]		
Highly Automated Mfg. (5 empl/acre)	x	x	x[4]	x[4]	x	x	x
Light Service Indus. (5-20 empl/acre)	x	x	x[4]	x[4]			
Heavy Mfg. (20-100 empl/acre)	x	x	x[4]	x[4]			

Notes:

[1]See Figure 7.7.

[2]Uses should be limited to activities which do not attract sustained large numbers of people. Suitable uses would be service stations, laundries, fast-food establishments.

[3]Assumes that the manufacturing activity meets maximum employee density.

[4]Assumes that the manufacturing activities are not noise-sensitive.

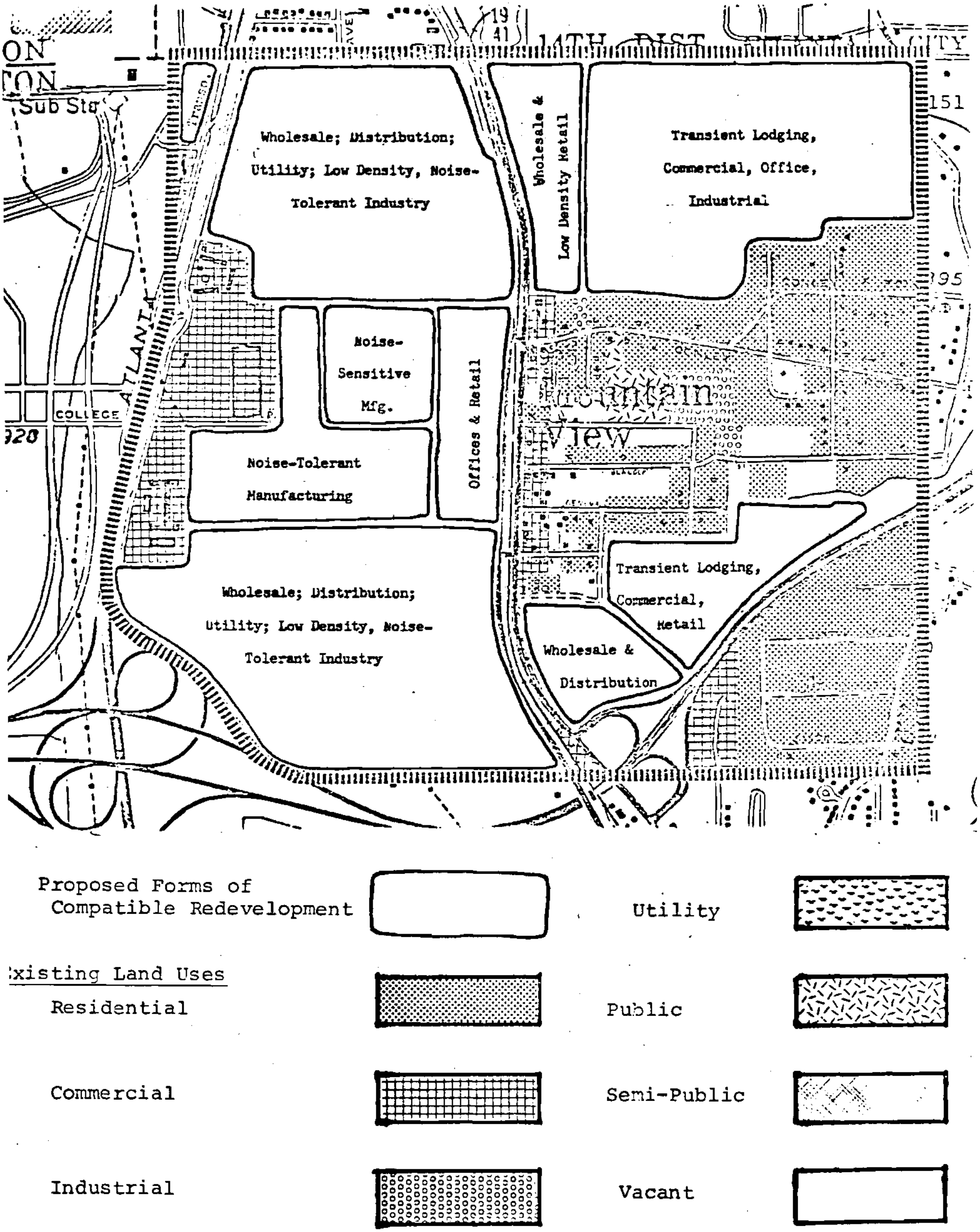


Figure 7.6. Redevelopment Plan for Mountain View

impacts in the area.

Several of the areas noted in Figure 7.6 refer to low-density uses in the accident-potential zones and to noise-tolerant or noise-sensitive types of activities. Several examples that meet these requirements are illustrated below:

<u>Accident-Potential Zone</u>[99]

Agricultural uses

Recreation areas

Equipment storage

Corporation yards

Single-story automobile parking

Single-story warehousing

Single-story municipal activities

<u>Noise-Tolerant Uses</u>[100]

Industrial or Manufacturing

Food and kindred products
Textile Mill products
Apparel
Furniture and fixtures
Printing, publishing
Fabricated metals
Rubber and miscellaneous plastic goods

Transportation, Communications, and Utilities

Railroad, rapid rail transit
Motor vehicle transport
Aircraft transport
Highway and street right-of-way
Auto parking
Utilities

Commercial or Retail Trade

Wholesale trade
Building materials retail
Automotive retail

Personal and Business Services

Auto repair services
Contract construction services

Noise-Sensitive Uses[101]

Industrial or Manufacturing

Professional, scientific, and controlling instruments

Transportation, Communications, and Utilities

Communication

Commercial or Retail Trade

General merchandise retail
Food retail
Accessories and apparel retail
Eating and drinking places

Personal and business services

Finance, insurance, and real estate
Personal services
Business services
Professional services
Indoor recreation services

Outdoor recreation

Playgrounds and neighborhood parks
Community and regional parks
Nature exhibits
Resorts and group camps

It should be noted that accident-potential guidelines take precedence over noise-compatibility standards in the APZ. For example, a proposed manufacturing activity will not be acceptable in the APZ if the employee densities are excessive, even if the activity is not affected by extreme noise levels.

One constraint that is not addressed in the land use plan is airspace limitations. It is assumed that the various buildings in each of the different areas would not exceed the permitted height limits. This is a reasonable assumption, since the strictest height limitation noted on Figure 7.6 is 115 feet. Most buildings that are typically found in commercial or industrial parks do not exceed 100 feet or 8-10 stories in height. Height restrictions would have the greatest influence on appurtenances, such as water towers, radio antennae,and storage bins.

Many of the possible uses that are shown on the plan may not be economically feasible, based upon market needs and individual locational requirements. For instance, it is unlikely that the area north of Conley Road would be suitable for transient lodging. However, the uses that are presented illustrate the potential uses available for the land, within the constraints of the airport environment.

The proposed plan provides the flexibility to adjust individual area requirements, based upon market demand. For instance, the relative sizes of the noise-sensitive area and the office and retail space situated west of Highway 19/41 can be adjusted to suit current market needs. Also, the existing motels and commercial area adjacent to the Interstate Highway 75 can be converted to industrial uses if and when economics require such a change.

CHAPTER EIGHT

CONCLUSIONS

Planners and public officials must balance the benefits of airports with the unavoidable problems and impacts that accompany them. To accomplish this, the city must be prepared to plan for the problems, while the airport must be operated with the best interests of the city in mind. Mr. Eddie Holohan, Assistant to the General Manager at Los Angeles International Airport, has appropriately remarked, "...there is no single, simple solution to the problems that an airport creates. What can be done is to take every step possible that will help reduce the problem. By a combination of such efforts, the impact of airport operations can be reduced to acceptable limits."

A comprehensive approach to the many different aspects of airport impact is essential. Advances in aircraft and their operation may significantly reduce the airport noise problem, thereby reducing the noise impact that must be planned for. The importance of quiet aircraft programs can be greatly emphasized by illustrating the costs and effects of other alternatives to the airport noise problem. The proper balance of techniques such as these will only be reached through a comprehensive analysis of all of the problems and their potential solutions.

The results of the studies in this thesis can be synthesized into four basic areas: the problems of relocation programs; the need to consider the hazards of potential aircraft accidents; the importance of minimizing airport impact on a community; and the prospects for new directions in land use and development around airports. Each of these topics are discussed below.

Relocation: A Solution, or a New Problem?

One method of dealing with a problem such as airport impact is to move away from it and this has been precisely the strategy that has been employed in cities such as Atlanta and Los Angeles. The costs of these programs have been large. Atlanta's 16 million-dollar relocation program will move 440 families from the Mountain View area, while Los Angeles is paying over 300 million dollars to relocate 2,000 families. While these costs are substantial in themselves, a much greater cost faces future relocation projects in Atlanta and around other major airports.

An analysis of the existing situation around Atlnata's airport reveals several important items. First, the land around the airport is highly developed. There is less vacant land in high-noise impact zones than there is in moderate-impact zones. Furthermore, residential densities are higher immediately around the airport than for other areas. Finally, the economic level of the people living closest to the airport is relatively low, as measured by house value and number of families with income below poverty levels. Projects in the future may require moving many low-income families from areas around airports. This could potentially place a great strain on the inventory of low-income housing.

Displacement of families from areas surrounding the airport must be accompanied by new housing to accommodate these people. Many of the relocatees may be able to find new homes in the private housing market. However, it is likely that many more will not be able to afford the more expensive rents or house payments in these other areas.

Planning for this new housing should begin now before large-scale relocations begin. The areas that are most likely to be part of a relocation program can be identified and the population characteristics studied to determine what their housing needs will be. Public and private sector housing plans should consider these requirements.

Property acquisition and family relocation may be the only reasonable alternative in many instances of severe airport impact. In many areas noise levels or accident potential cannot be minimized enough to allow activity such as residential use to continue. However, acquisition and resident relocation should be considered only when conservation of an area by some other means is not possible and after all possible alternatives have been considered.

Accident Potential: The Planner's Responsibility

The excellent safety record that commercial aviation has compiled has lulled most of the public and their representative officials into a false sense of security. Accident potential around airports has not been seriously considered in planning and development programs. However, the fact is that aircraft accidents do occur and they happen most often near airports. It is logical, therefore, that accident potential should be an important part of planning the areas surrounding an airfield.

Aircraft accidents are generally of less concern to the general public because they do not affect people every day. People are most concerned about problems that are easily recognized such as noise, air pollution, and crime. Since there is little public pressure to consider the problem of accident potential, there has been little legislative activity to protect against it.

One advantage in dealing with accident potential is that its probable impact zone covers a relatively small area, as compared to noise-impact zones. For Hartsfield International, the accident-potential zones cover less than two square miles, as compared to more than 100 square miles in the noise-impacted area (L_{dn} 65 and above). The techniques are available to identify accident potential areas and the land can remain in limited productive use once they are established. However, positive action must be taken to insure that accident-potential zones are properly planned and controlled.

Minimizing Airport Impact

Since airports will never be completely free of noise from aircraft, or totally safe from potential accidents, development around airfields must be prepared to account for these problems. As previously noted, over 100 square miles of land are impacted by noise from aircraft using Hartsfield airport. To use this land productively, the effects of aircraft operations will have to be considered.

Minimizing airport impact can take several forms. It may involve the comprehensive planning and development controls, or technological methods such as soundproofing. In limited cases it can mean the use of compensation to account for the reduced utility of a space as a result of airport impact.

Comprehensive planning and development controls potentially offer an effective method of regulating growth around airports. However, to be effective, they must be administered on a regional scale. At Hartsfield International, the airport directly affects eight municipalities and three counties. At the present time, there is no regional administration of development controls around the airport.

The City of Atlanta and the Atlanta Regional Commission are in a position to insist on local conformance to development controls over land surrounding the airport. The City of

Atlanta, as the airport operator, initiates grant applications and program funding requests for projects affecting the airport. Under the new ADAP program, funding is available to help alleviate airport impact. The City of Atlanta should require adoption of specific land control regulations before it will initiate program action for a community that is suffering from airport operations. The Atlanta Regional Commission is in a similar position, as the area clearinghouse for federally-funded and area-wide projects.

Land use controls and development regulations should be implemented before any major redevelopment around airports is undertaken. Police power regulations can be applied to control types of land use in noise-impacted areas or accident-potential zones. Such regulations can also provide policy guidance for planners who prepare programs for the redevelopment of areas around airports.

Soundproofing offers a potentially effective method of preserving existing development in noise-impacted areas. However, some additional correction may have to be made for the reduced utility of the outside space. The results of the study conducted by Wyle Laboratories are particularly interesting in this regard. A post-improvement survey indicated that owners of homes with the heaviest soundproofing felt the outside noise levels made their homes undesirable, even though interior noise levels were satisfactory.

The generalized study of Mountain View indicated a distinct need for certain types of data related to noise abatement. Studies are needed to determine the costs to provide soundproofing improvements for houses in the local area and to determine the permissible noise levels for interior residential areas. Also, a means of evaluating the impact of exterior noise, and possibly determining the economic value of exterior noise levels is needed. Given these data, an accurate evaluation of an area can be conducted to determine the need for acquisition, soundproofing, or compensation to alleviate the problems of airport noise.

The benefits of adapting existing land uses to the airport environment are significant. In Atlanta over 23,000 homes are in an area rated as unacceptable for residential use because of excessive noise impact. Some residents in these areas must relocate because of the magnitude of the noise problem. However, for many, all that may be needed is some means of insulating their home to provide protection from the excessive noise levels. This degree of flexibility can offer an extra dimension in planning around airports and can minimize the requirements for relocation.

New Directions

Redevelopment of the areas around airports offers new opportunities for economic expansion and redevelopment. However, an analysis of the development potential near airports requires the simultaneous consideration of many different criteria. The planner must be aware of environmental limitations, safety precautions, operational restrictions, market capacity and needs and economic and social conditions.

The analysis of Mountain View in Chapter Seven indicates that there is potential for the development of several different types of productive land uses near an airport. Various forms of commercial, industrial, and even some transient lodginq, are environmentally acceptable in the area. However, single or multi-family residential development are not recommended.

Among productive forms of intensive land use, industrial development is the most compatible with the airport environment. Industrial uses are the most tolerant of noise and can be adapted to the accident-potential restrictions. Industrial parks offer an excellent management technique for the development of areas around airports. They afford a method of development that can be carefully controlled to restrict the growth of incompatible land uses.

Some forms of commercial development are compatible with the noise impact around airports, but are generally unacceptable in accident-potential zones. Enclosed shopping malls offer an option for development that can overcome the noise levels around airports, but are suitable only in areas where accident potential is not a factor. Commercial development may be appropriate as a part of an industrial park, where manufacturing is the primary purpose of the area and a commercial district is needed to satisfy employee needs.

An important fact to remember in any redevelopment project is that market requirements will have the greatest influence on what type of development is appropriate for an area. No degree of site design or environmental planning will make a development successful, if the market will not support it. Environmental planning and area economic analysis should occur simultaneously to insure that the proper development form is recommended for a particular area. Therefore, the environmental planner and the economic development specialist should establish a cooperative working relationship in the early stages of planning a redevelopment project.

In summary, airport development must grow within the framework of total community needs. The adverse impacts of airport operations must be balanced with the economic benefits that they bring. The problems of noise and the very real hazards of accident potential must be met. By seeking solutions to these problems, planners can contribute significantly to the security of airports in urban areas and the well-being of the general public.

FOOTNOTES

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[31]*Ibid.*, p. 11.

[32]*Ibid.*, p. 17.

[33]*Ibid.*, p. 18.

[34]*Ibid.*, p. 24.

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